ENERGY ENGINEERING ANALYSIS

CUTLER ARMY COMMUNITY HOSPITAL

AND ASSOCIATED FACILITIES

FORT DEVENS
MASSACHUSETTS

CONTRACT NO. DACA 65-80-C-0003

VOLUME 1

EXECUTIVE SUMMARY

OCTOBER 1985

Reynolds, Smith and Hills
Architects-Engineers-Planners,
Incorporated

FINAL SUBMITTAL

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DEPARTMENT OF THE ARMY
CONSTRUCTION ENGINEERING RESEARCH LABORATORIES, CORPS OF ENGINEERS
P.O. BOX 9005
CHAMPAIGN, ILLINOIS 61826-9005

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ENERGY ENGINEERING ANALYSIS PROGRAM

CUTLER ARMY COMMUNITY HOSPITAL AND ASSOCIATED FACILITIES

VOLUME 1 - EXECUTIVE SUMMARY

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VOLUME 1 - EXECUTIVE SUMMARY

1.0 INTRODUCTION

1.0 INTRODUCTION

In February 1980, the Corps of Engineers, Norfolk District, initiated Contract No. DACA65-80-C-0003 with Reynolds, Smith and Hills, Architects-Engineers-Planners, Inc. of Jacksonville, Florida. This contract called for the performance of Energy Engineering Analysis Programs (EEAP) at three U.S. Army installations: Fort Devens, Massachusetts; Letterkenny Army Depot, Pennsylvania; and Seneca Army Depot, New York. The objective of these programs was the identification, evaluation and development of programming documents for energy conservation projects which meet the criteria of the Army's Energy Conservation Investment Program (ECIP) and other funding mechanisms. The basic contract was modified by the Corps of Engineers several times to include additional increments of energy-related studies at each of the three installations.

Work performed thus far for Fort Devens has included the following increments:

- A - ECIP's for buildings and processes
- B - ECIP's for utilities and energy distribution systems and EMCS
- C - Solar and renewable energy systems
- D - Wood-Fired Steam Generation Plant
- E - Coal conversion
- G - Projects identified in Increments A & B that did not meet ECIP criteria

In order to fulfill expanded requirements of the Army Facilities Energy Plan, the Corps of Engineers extended the contract with RS&H to include a detailed energy audit of the Cutler Army Community Hospital and Associated Facilities at Fort Devens, Massachusetts. The Associated Facilities are the Vail Dental Clinic and the Oral Health Center. The energy audit consists of a field survey, analysis of energy conservation opportunities, and development of 1391's and other programming documents for qualifying projects. The metering plan option was not included as part of this contract.

2.0 EXISTING CONDITIONS

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2.1 FACILITY DESCRIPTION

2.1.1 Cutler Army Community Hospital

Cutler Army Community Hospital (CAH), building number 3654, is a full service health care facility opened in December 1970. It is located at Fort Devens near the town of Ayer, Massachusetts. Originally designed for 110 beds, the hospital presently maintains approximately 85 available beds. An average of 50 percent of the patient wards were occupied during Fiscal Years 1982 and 1983.

During periods without significant military conflict, the hospital is basically used as a large scale clinic with the capacity to perform minor surgery. Approximately half of the patient wards and the entire delivery room and nursery area are currently being used for office and storage space. However, this is a temporary measure and may be changed at any time.

The facility is three stories high with approximately 120,000 square feet of floor area. The building shell is brick and concrete construction. Space conditioning is provided by an absorption chiller and two steam boilers that can fire either fuel oil or natural gas. Electricity is supplied by the New England Power Company.

Although many areas of the hospital are used 24 hours per day, the schedules for different areas vary widely. The operating room and all clinics are used 9½ hours per day, five days per week. Administrative areas including the pharmacy and emergency room waiting areas are utilized 9½ hours per day, six days per week. The kitchen and dining room are open about 16 hours per day, seven days per week. The remaining areas emergency room, labs, patient wards, and boiler room, are used 24 hours per day, seven days per week.

2.1.2 Associated Facilities

Adjunct to the Hospital are two associated facilities which provide outpatient dental services. These facilities are the Vail Dental Clinic (Building 2729) and the combined Oral Health Center and Dental Activity Headquarters (Building 2283).

The Vail Dental Clinic (VDC) provides facilities for dental treatments including fillings, extraction, periodontal surgery, and the manufacture and fitting of both temporary and permanent dental prosthetics. The building contains a reception area, a waiting area, several offices and supply rooms, examination and treatment rooms, and a laboratory for manufacturing dental prosthetics. It is a one story CMU structure with a brick veneer outer surface and shallow sloped roof. The windows are fixed (do not open) with temperature, humidity and ventilation being maintained by a multizone HVAC system. The air handling system for the HVAC system is located in the equipment room housed in a partial basement. The HVAC condenser (heat rejection unit) is located on grade adjacent to the equipment room. The domestic water heater and various other items of mechanical equipment are also located in the partial basement.

The Oral Health Center - Dental Activity Headquarters (OHC) is a two story wood frame structure with a hip roof having vertical end louvers. The building has been extensively renovated and is in good condition to serve its present functions. Activities performed at the Oral Health Center including tooth cleaning, examination, and taking of dental X-rays. A training room is provided for making presentations to small groups. All patient related functions are located on the second floor. Dental Activity Headquarters functions are located on the first floor. This floor provides offices, a large and small conference room, a secretarial area, and storage for files and office supplies.

2.2 FACILITY ENERGY USE DATA

2.2.1 Historical Data

Cutler Community Army Hospital

Three years of energy data for the hospital were collected and analyzed to determine the energy use patterns of the facility in its existing condition. The primary energy sources for the hospital are electricity, natural gas and fuel oil. As shown in Table 2-1 and Figure 2-1, total energy use has varied little over the past three years, although the weather (see heating degree-days) has. This indicates that changes in the weather do not significantly influence the hospital's energy consumption. Electricity use has remained constant and fuel oil has replaced natural gas at approximately the same level of annual consumption. Natural gas and fuel oil use were combined and plotted as "fossil-fuel" in Figure 2-2 along with electricity to show the monthly energy use values for the past three years. Total energy consumption is plotted in Figure 2-3.

Figure 2-4 contains the energy use breakdown by type for FY 83. The largest share is fuel oil, approximately 61,981 MBtu, because it is used year-round to fire the boiler for space heating, absorption cooling, and process loads. Annual electricity use is 34,864 MBtu or about 3 million kilowatt hours. The total consumption for FY83 for all fuel types is 96,845 MBtu.

Monthly data for the three past years were averaged for verification of the DOE-2 computer simulation program (Figures 2-5 and 2-6). Figure 2-5 describes the average electrical energy consumption over a three-year period. The average fossil-fuel consumption over the same period is shown in Figure 2-6. The average electrical and fossil-fuel energy usuage over the past three years is 2.91 million kilowatt hours (33,756 MBtu) and 61,170 MBtu, respectively. Although historical demand data for the hospital are not available, the demand meter was read often during the facility survey. The results are contained in Figure 2-7 and indicate the hospital electricity demand during the heating season. This is assumed to be typical.

The peak electrical demand in the cooling season is estimated in a different manner. Upon arrival at the hospital, the demand meter read 510 kW. Since the meter has not been reset in several years, according to hospital personnel, it can be assumed that this is a good estimate of the cooling season peak. The difference in the winter and summer time peaks are due to the cooling tower operation.

Associated Facilities

Primary energy sources for the Associated Facilities are electricity, natural gas and No. 2 fuel oil. Electric energy is used for A/C, lighting, and for miscellaneous equipment in both buildings. Fuel oil is used for space heating and heating of domestic hot water in both buildings. Natural gas is available at the Vail Dental Clinic, but has been used only as a backup energy source for space heating and for heating of domestic hot water when the boiler is not operating. Figure 2-8 indicates the expected energy use by type. As fuel

TABLE 2-1. CAH HISTORICAL ENERGY USE (MBtu)

FUEL TYPE	FY81	FY82	FY83
Fuel Oil	7,305	58,089	61,556
Nat. Gas	50,654	5,608	767
Elect.	35,751	34,058	34,522
TOTAL	93,710	97,755	96,845
Heating Degree Days	6,986	7,224	6,175

FIGURE 2-1

CUTLER ARMY COMMUNITY HOSPITAL
HISTORICAL ENERGY CONSUMPTION
BY FUEL TYPE

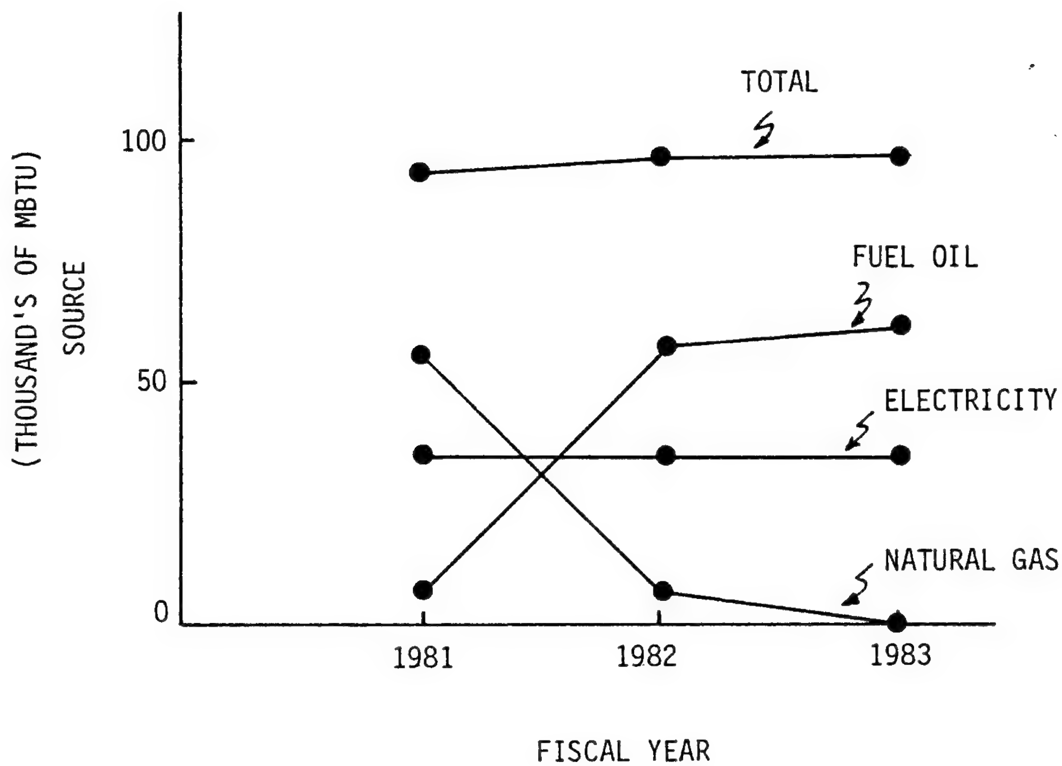


FIGURE 2-2

CUTLER ARMY HOSPITAL
HISTORICAL ENERGY USE BY MONTH

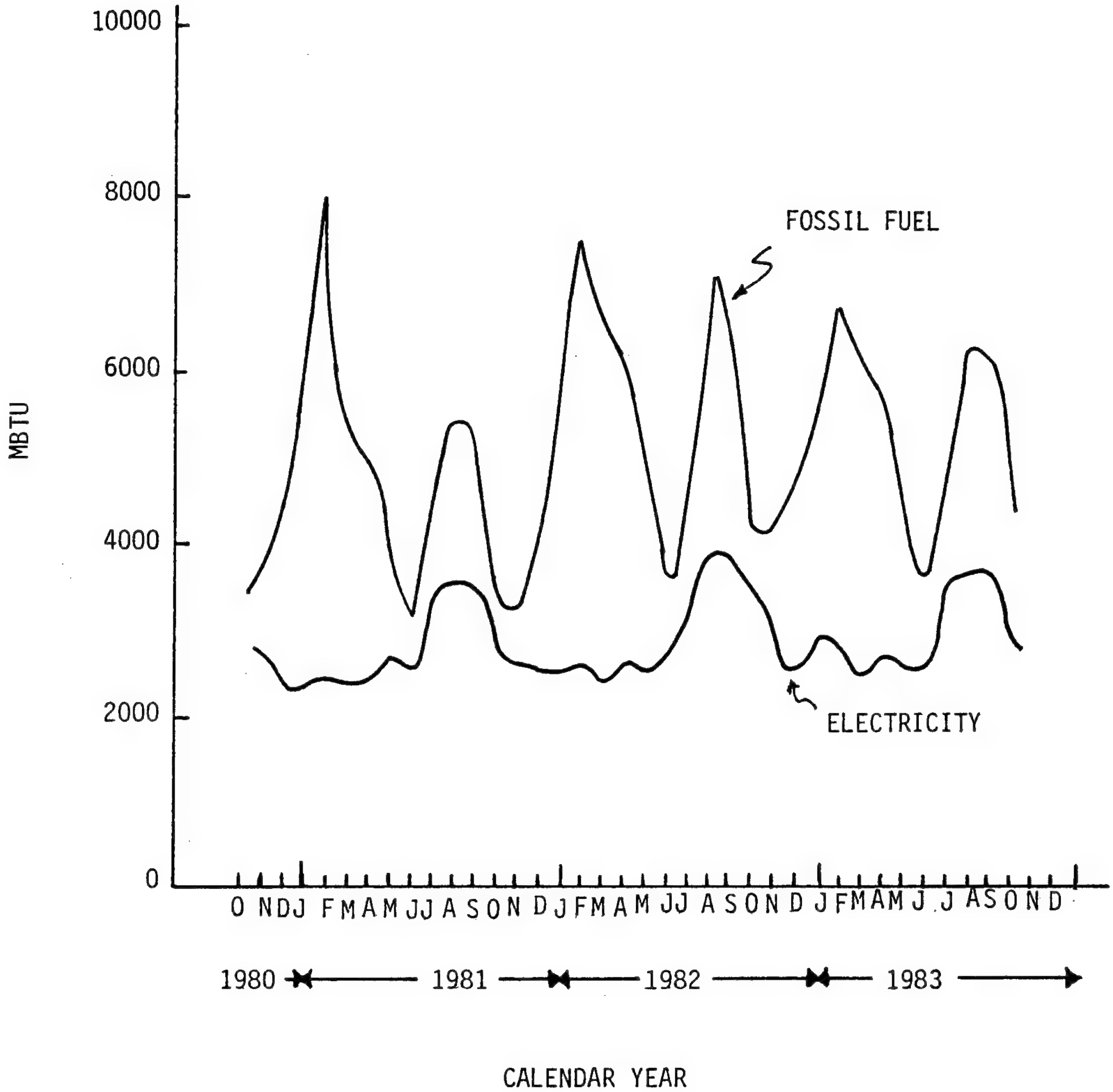


FIGURE 2-3

CUTLER ARMY HOSPITAL
MONTHLY TOTAL ENERGY CONSUMPTION

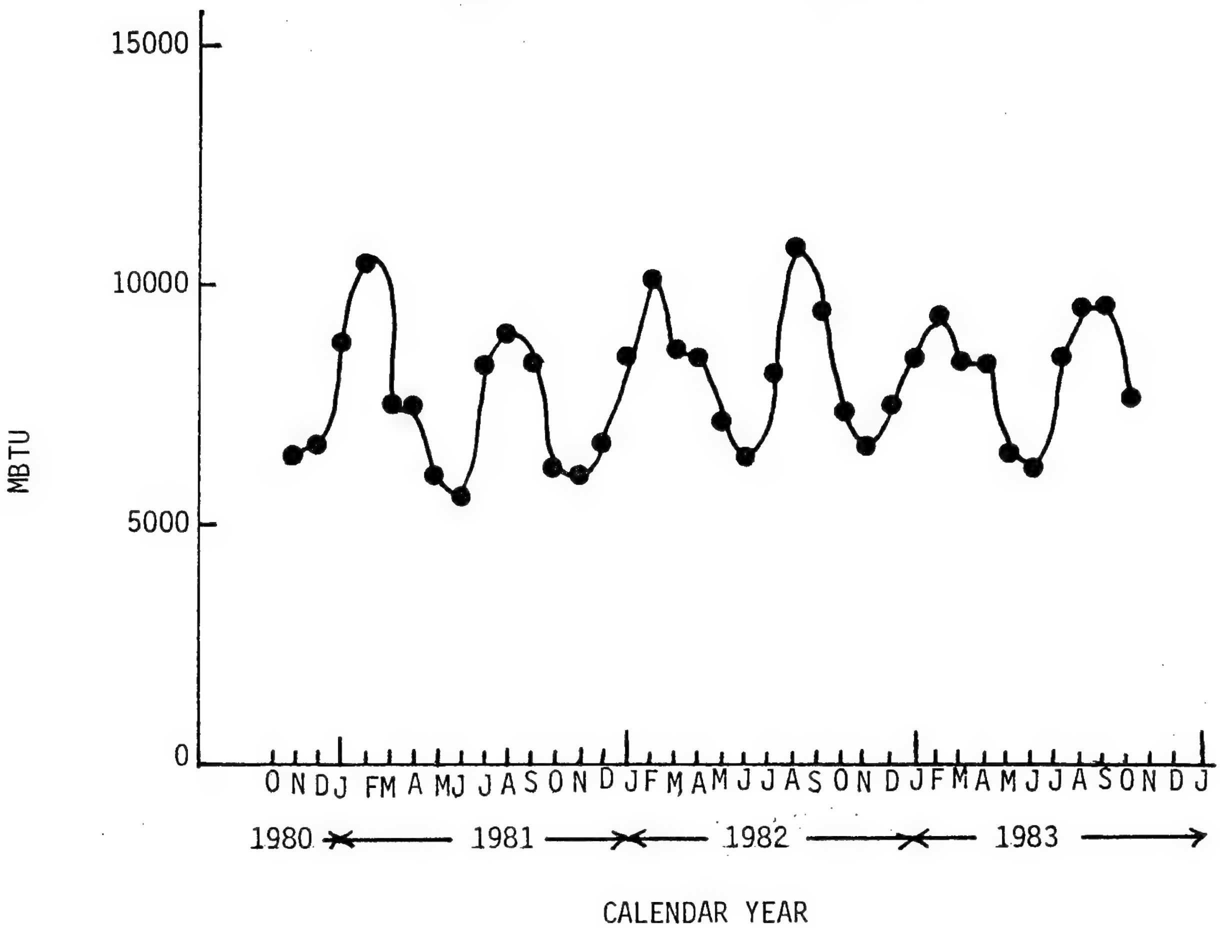
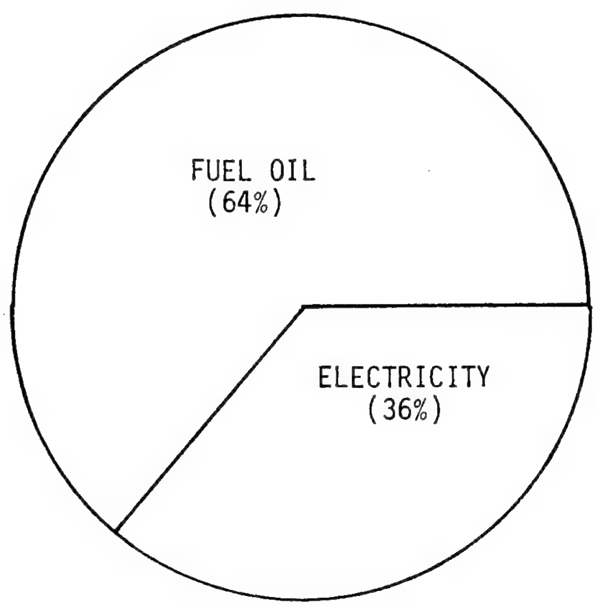


FIGURE 2-4

CUTLER ARMY HOSPITAL
ENERGY USE BY TYPE - FY83



TOTAL: 100% = 96,845 MBTU

FIGURE 2-5

CUTLER ARMY HOSPITAL
AVERAGE ELECTRICITY USE BY MONTH
FY81-83

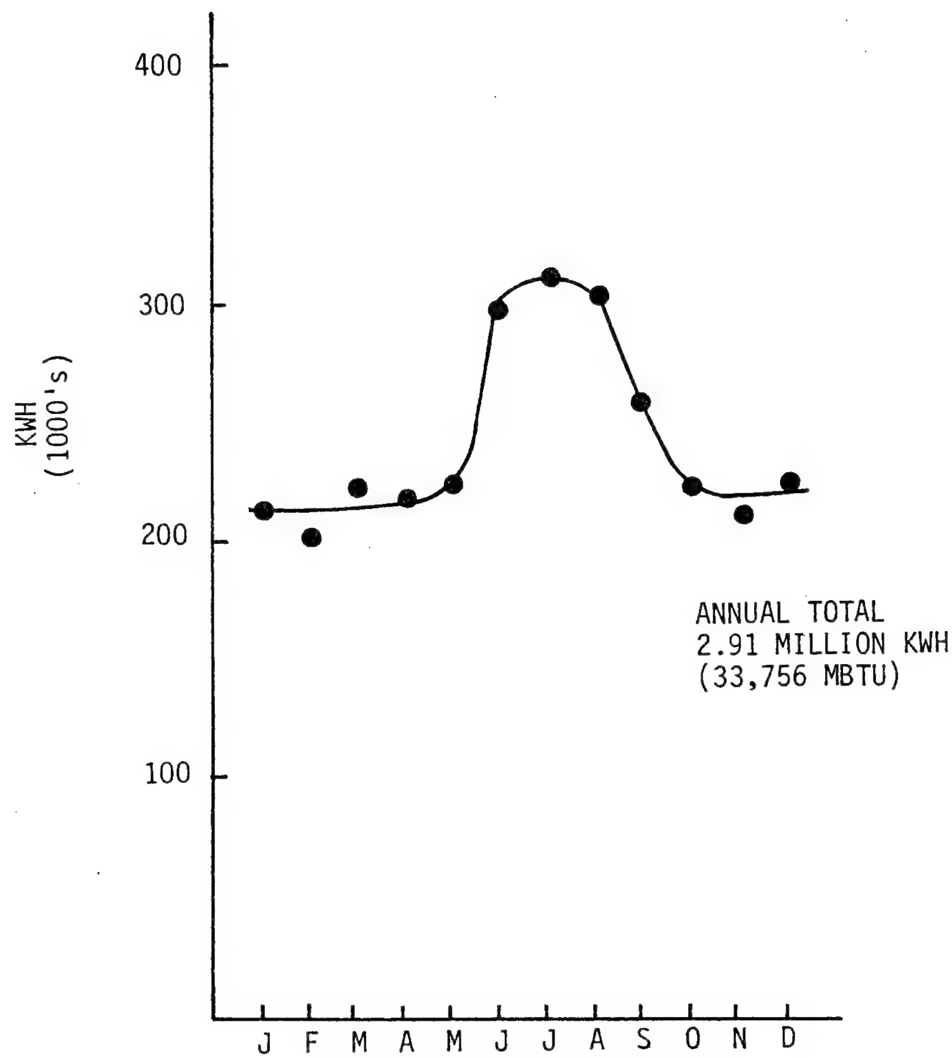


FIGURE 2-6

AVERAGE FOSSIL-FUEL CONSUMPTION
CUTLER ARMY HOSPITAL
FY81-83

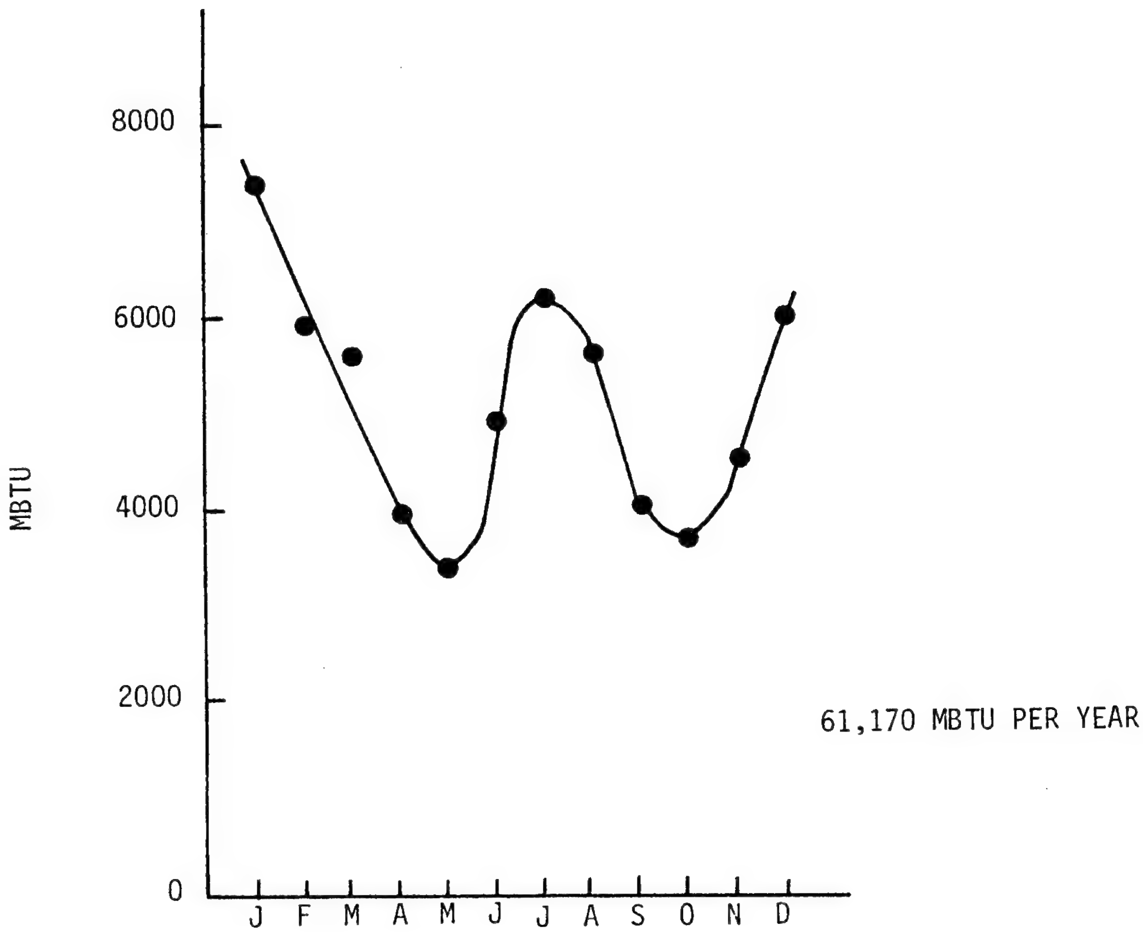


FIGURE 2-7
CUTLER ARMY HOSPITAL
ELECTRICAL DEMAND
(OBSERVED)

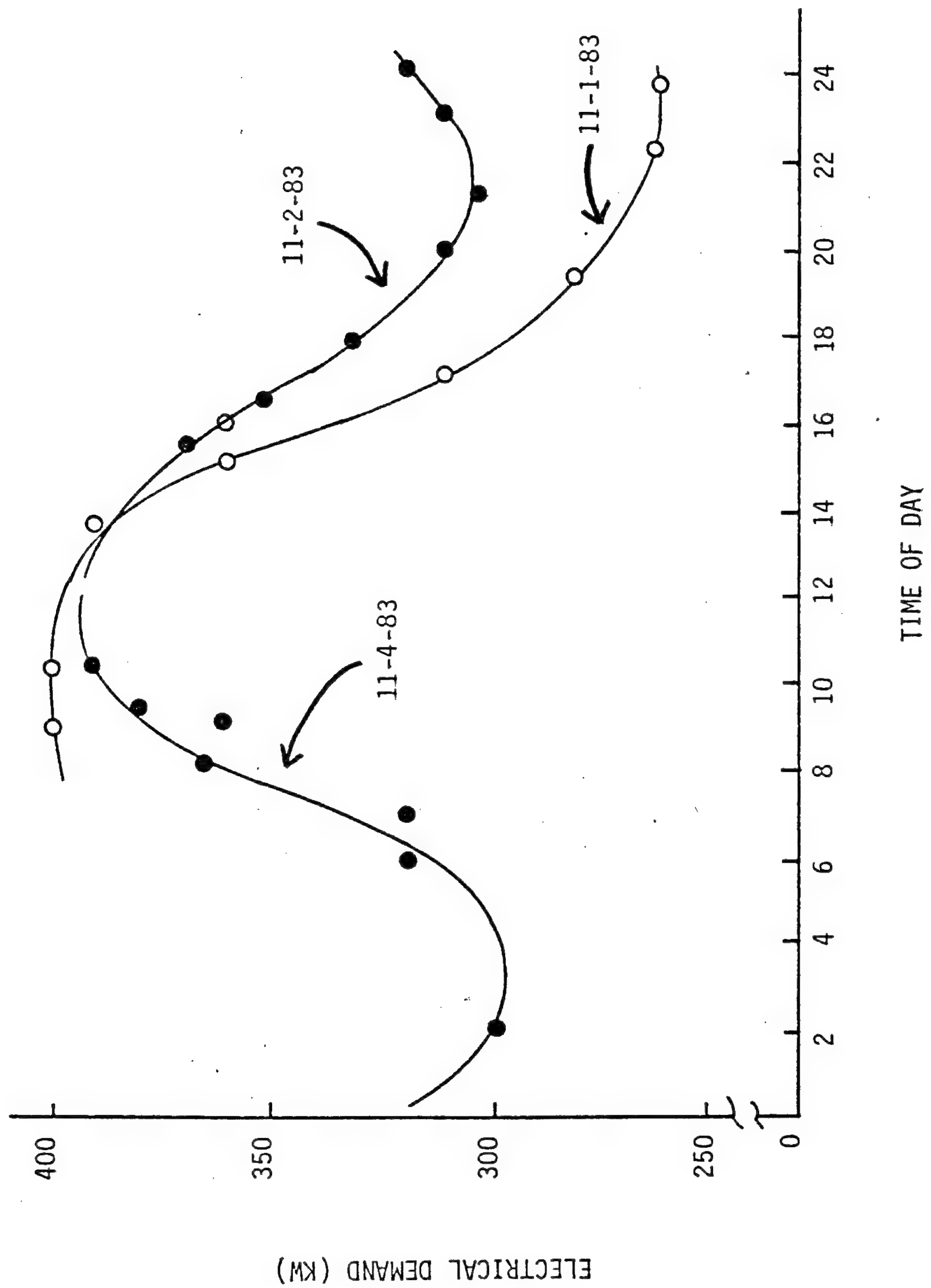
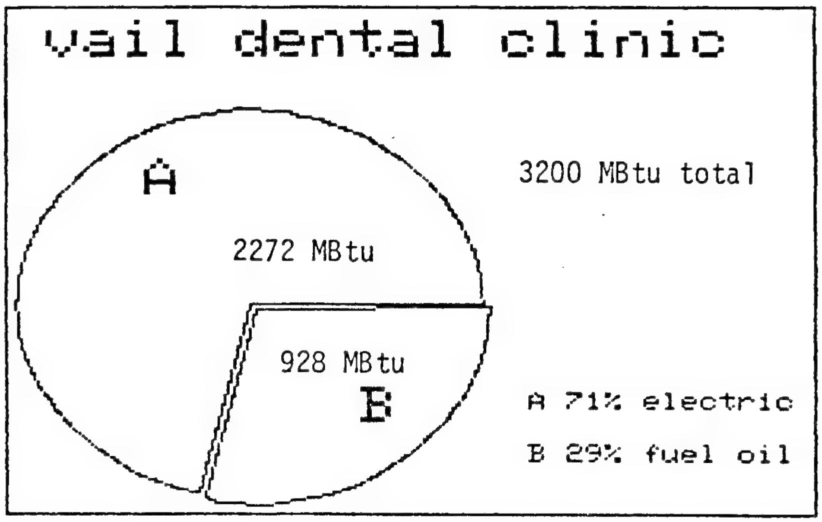


FIGURE 2-8 ENERGY USE BY TYPE

(Before Implementation of Projects)



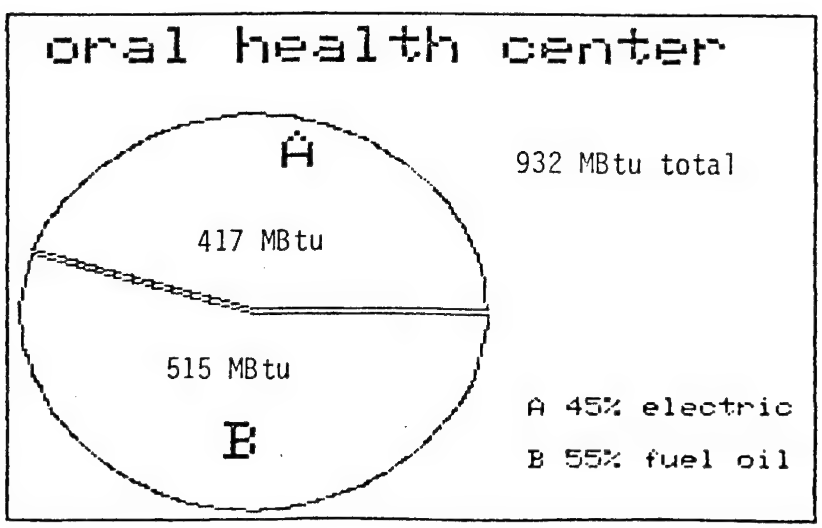


Table 2-8 - Number 2 Fuel Oil Deliveries

Vail Dental Clinic (Building 2729)

Year*	Amount
1982-83	5387 Gallons (747 MBTU)
1983-84	8056 Gallons (1117 MBTU)

Oral Health Center
Dental Activity Headquarters
(Building 2283)

Year*	Amount
1978-79	5444 Gallons (755 MBTU)
1979-80	3259 Gallons (452 MBTU)
1980-81	Not Available Not Available
1981-82	4517 Gallons (627 MBTU)
1982-83	4329 Gallons (600 MBTU)
1983-84	3958 Gallons (549 MBTU)

* Fuel delivered from June through May except for 1978-79 and 1979-80 which is from October through September.

usage records are kept only for fuel oil deliveries, it is not possible to develop historical energy use profiles directly. Expected energy use was calculated for a typical year using the DOE-2 computer program. Results, showing energy use by type, are shown in Figure 2.8.

The only information available regarding energy consumption by the Associated Facilities consists of monthly oil delivery records. Records for Vail Dental Clinic show delivery of 5,387 gallons of No. 2 oil from June 1982 through May 1983 and 8,056 gallons from June 1983 through May 1984. Records for the Oral Health Center show delivery of 4,329 gallons of No. 2 fuel oil from June 1982 through May 1983 and 3,958 gallons from June 1983 through May 1984. More complete historical data is provided in Table 2-8.

2.2.2 Energy Costs

2.2.2.1 Electricity

Electricity for Ft. Devens, the hospital and Associated Facilities, is supplied by New England Power Company. The electrical consumption at the hospital is primarily due to lights and electrical equipment. However, the air conditioning cooling tower does contribute a considerable amount during cooling months. Electrical power consumption at the associated facilities is primarily due to lights, equipment, and air conditioning systems.

The cost of electricity to Ft. Devens is $0.02475 per kilowatt-hour for energy and $10.13 per kilowatt per month for demand (May 1983). Neither the hospital nor the associated facilities pay a separate demand charge. There is no ratchet clause in the rate schedule. A kilowatt-hour of electrical energy represents 11,600 Btu of source energy.

2.2.2.2 Natural Gas

Natural Gas at Ft. Devens is supplied by Boston Gas Company. Natural gas consumption at the hospital has decreased drastically since FY 81. When the price of natural gas exceeded that of No. 4 fuel oil, the more economical fuel oil was substituted. Natural gas is not available at the Oral Health Center but is available at the Vail Dental Clinic where it is used as a backup fuel for space heating and domestic water heating, and to supply fuel to small burners in the laboratory.

The cost of natural gas supplied to Ft. Devens is $0.5808 per therm in excess of 1040 therms (July 1983). The first 1040 therms costs $726.85 each month. A therm of natural gas represents 100,000 Btu of energy. There are 1.031 MBtu in 1,000 cubic feet of natural gas.

2.2.2.3 Fuel Oil

Fuel oil at Ft. Devens is supplied by several different contractors. However, No. 4 fuel oil is the only type used at the hospital in any significant quantity. No. 4 fuel oil is used to fire the two steam boilers in the hospital plant. The steam is used for space heating, space cooling (for the absorption chiller), reheat coils, humidification, domestic hot water, and various other devices such as stills, sterilizers, steam kettles, dishwashers, and steam tables. No. 2 fuel oil is stored on-site for the hospital's emergency generator.

No. 2 fuel oil is also used to provide energy for space heating and domestic water heating at both the Vail Dental Clinic and the Oral Health Center.

The cost of No. 4 fuel oil supplied to Ft. Devens and the hospital is $0.80 per gallon. No. 2 fuel oil costs $1.04. Both are contract prices for FY 84. No. 4 fuel oil contains 144,000 Btu per gallon and No. 2 fuel oil contains 138,700 Btu per gallon.

3.0 METHODOLOGY

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3.1 SITE SURVEY

The site survey of the Cutler Army Community Hospital was conducted the first week of November 1983 by a team of engineers and technicians. The site survey of the Associated Facilities was conducted the first week of May 1984. The purpose of these surveys was to obtain data relative to the construction, occupancy, functional use, energy consumption, completed or programmed energy conservation or other modifications, and energy consuming equipment and systems. These data were assimilated, studied and organized to identify energy savings projects and operating and maintenance improvements.

3.2 COMPUTER SIMULATION

The energy analysis for the Cutler Army Community Hospital and for the Associated Facilities was performed using the DOE-2 computer simulation program. DOE-2 is an energy analysis computer program developed by the U.S. Department of Energy at Lawrence Berkeley Laboratory, Berkeley, California. The computer program is recognized nationwide as a state-of-the-art building energy analysis tool. Appendix B contains a computer run example with an explanation of all output reports. Also included is a section summarizing the program methodology and energy evaluation capabilities.

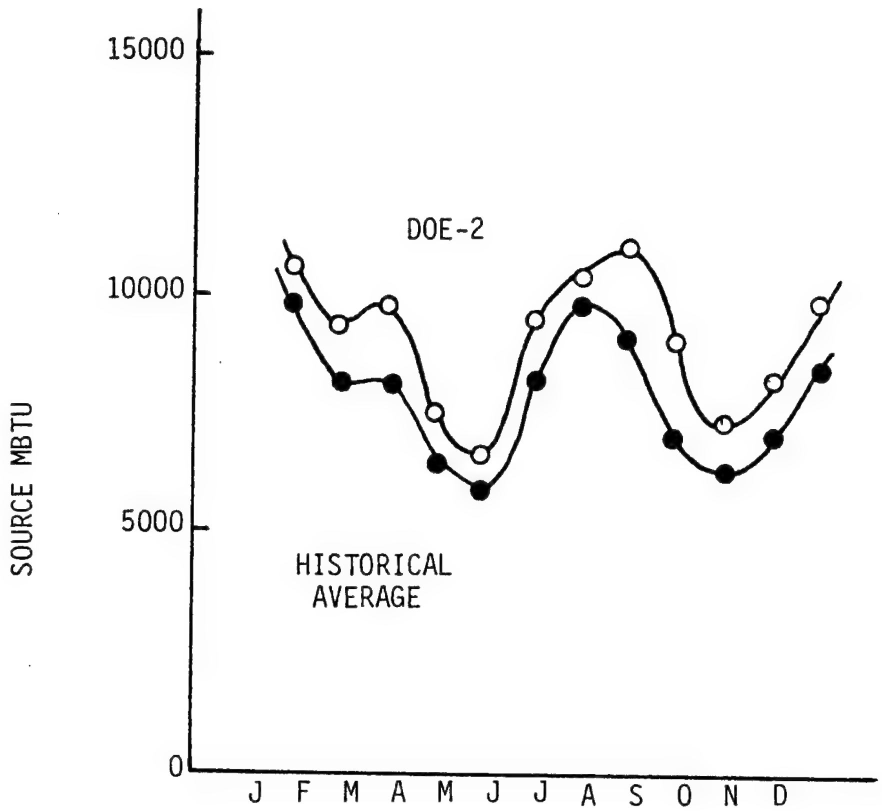
DOE-2 was programmed to develop a theoretical energy use baseline to evaluate energy saving projects. The results for the hospital are plotted in Figures 3-1, 3-2 and 3-3 to compare with the historical three-year monthly average. The DOE-2 baseline total annual energy use is within 13.8% of the historical average. Figure 3-4 shows the breakdown of total energy consumption by end use.

For the Associated Facilities, Figure 3-5 shows the breakdown of total energy consumption by end use. These values were calculated using actual temperatures and air supply and exhaust rates measured during the site survey. Calculated values for fuel oil consumption are within ten percent of actual fuel deliveries for the most recent year. Monthly comparisons are provided in Table 3-1.

After the model was verified to represent an accurate simulation of energy use, adjustments were made to the indoor thermostat setpoints to comply with Department of the Army (DA) regulations (AR 11-27 and TM 5-838-2). By doing this, ECO's would not take credit for energy savings derived by operating a DA facility at its authorized temperature settings. This model is then used as a baseline for all energy savings calculations. Results of these runs are listed in Table 3-2.

FIGURE 3-1

CUTLER ARMY HOSPITAL TOTAL ENERGY USE
DOE-2 COMPARISON



	TOTALS (SOURCE MBTU)
DOE-2	107,995
HISTORICAL	94,926

FIGURE 3-2

CUTLER ARMY HOSPITAL
ELECTRICITY USE
DOE-2 COMPARISON

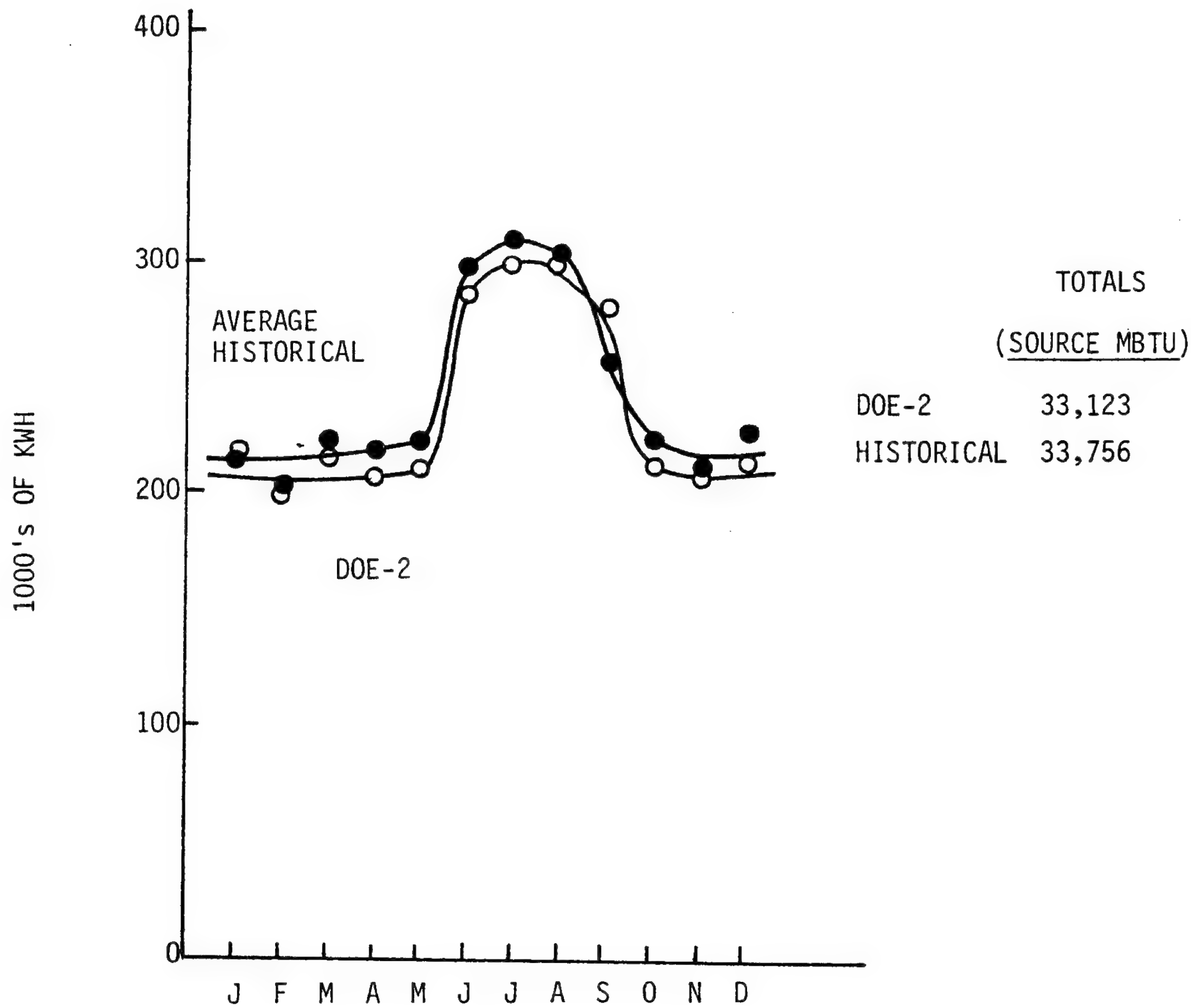


FIGURE 3-3

CUTLER ARMY HOSPITAL
FOSSIL FUEL USE
DOE-2 COMPARISON

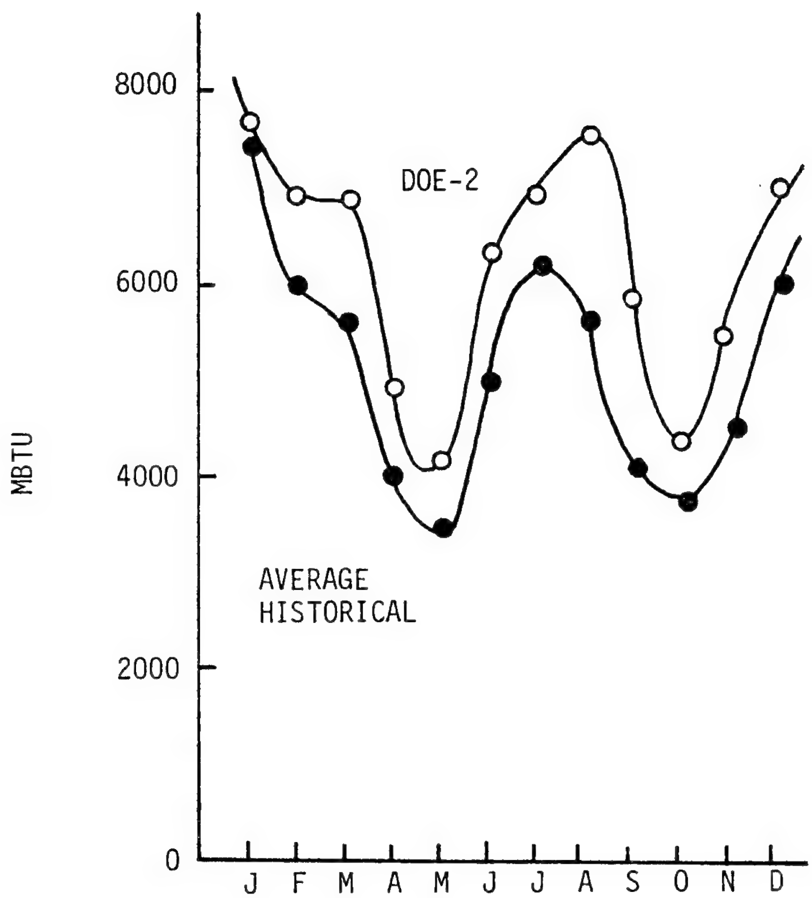
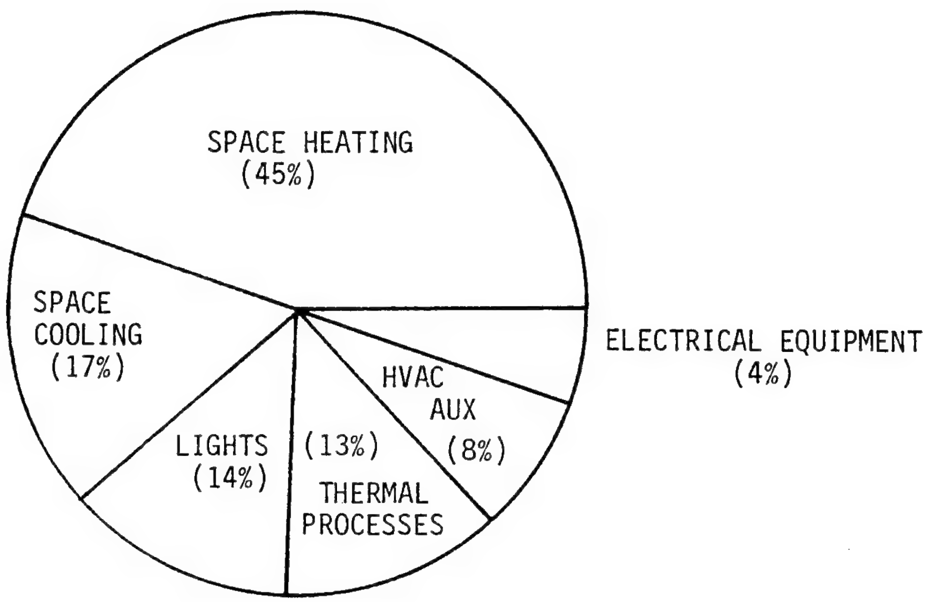


FIGURE 3-4

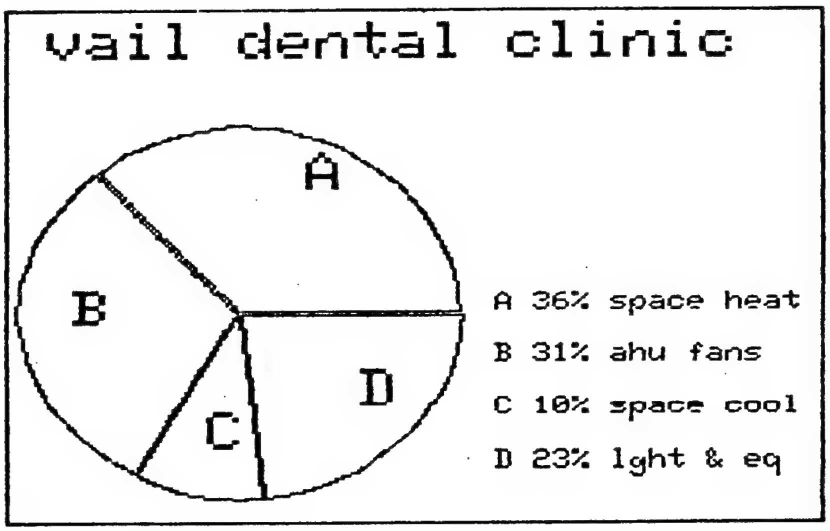
CUTLER ARMY HOSPITAL
ENERGY CONSUMPTION BY END USE



THERMAL PROCESSES
INCLUDE DOMESTIC HOT WATER

100% = 94,926 MBtu

FIGURE 3-5 - Annual Energy Consumption by End Use



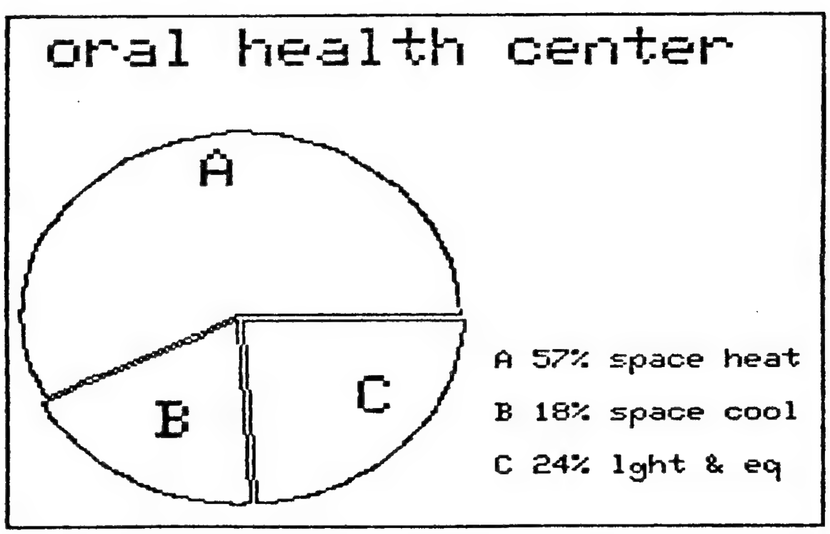


Table 3-1 - Comparison of DOE-2 Results with Annual Fuel Deliveries

Month	Building 2729 Vail Dental Clinic		Building 2283 Oral Health Center	
	Actual Fuel Delivered (MBtu)	Calculated Fuel Usage (MBtu)	Actual Fuel Delivered (MBtu)	Calculated Fuel Usage (MBtu)
June	0	0	0	0
July	0	0	0	0
August	0	0	0	0
September	0	0	0	0
October	0	79	0	35
November	7	113	99	62
December	300	163	143	86
January	247	181	112	94
February	79	170	47	93
March	150	159	51	86
April	334	85	0	41
May	0	56	97	18
TOTAL	1117	1006	549	515

Actual fuel deliveries based upon records for 1983-1984.

Calculated fuel usage from DOE-2 base line analysis.

Table 3-2. DOE-2 Analyses Results Summary

Hospital

Run ID	Description	SITE MBTU Elec	SITE MBTU Fuel-Oil
BS1	Existing Baseline	9,707	75,084
BAG	Baseline - Army Guidelines	9,658	68,971
WLI	Wall Insulation	9,652	68,345
RFI	Roof Insulation	9,654	68,607
DPN	Double Pane Windows	9,650	68,579
SB1	Day/Night Setback	9,200	62,484
SB2	Optimal Start/Stop	9,183	62,172
ZOP	Zone Optimization	9,646	68,448
HRC	Run Around Loop Heat Recovery	11,742	60,762
RED	Reduce Supply Air	9,428	65,129
RTA	Reduce Outside Air Intake (Return Air)	10,413	58,881
ECH	Electric Centrifugal Chiller	10,824	56,003
EC1	SB1 + HRC + RED + RTA + ECH	10,226	47,088

Vail Dental Clinic

Run ID	Description	SITE MBTU Elec	SITE MBTU Fuel-Oil
NIST	Existing Baseline	557	1,006
BASE	Baseline - Army Guidelines	668	928
NSB	Night Setback	464	515
RSET	Reset Cool Deck Temp	669	928
ENTH	Enthalpy Control	666	928
PANE	Double Pane Windows	665	852
ROOF	Roof Insulation	667	906
OSS	Optimal Start/Stop	467	492

Oral Health Center

Run ID	Description	SITE MBTU Elec	SITE MBTU Fuel-Oil
HIST	Existing Baseline	123	554
BASE	Baseline-Army Guidelines	123	515
NSB	Night Setback	122	360
CEIL	Ceiling Insulation	122	497
OSS	Optimal Start/Stop	122	344
COMB	Furnace, Night Setback, Insul.	122	290

4.0 ENERGY ANALYSIS

4.0 ENERGY ANALYSIS

4.1 QUALIFYING ECO's - Hospital

Nine ECO's were identified as having SIR's greater than one. These are summarized in Table 4-1 and described in the following subsections.

TABLE 4-1 QUALIFYING ECO's - Hospital

ECO's	Current Construction Cost ($)	SIR	Payback (yrs)	Applicable Funding
1. Reduce OSA Intake	393,335	1.77	8.4	ECIP
2. R-A-L Heat Recovery	83,585	1.88	10.8	ECIP
3. Replace Abs. Chiller	417,400	2.82	4.5	ECIP
4. Replace Blr. Economizer	57,700	2.99	4.7	ECIP
5. Replace Stnd. El. Motors	33,500	1.22	7.0	ECIP
6. Install Door Weatherstrip	464	7.99	1.7	OMA QRIP
7. Reduce Supply Air Volume	49,730	6.30	2.2	PECIP/ECIP
8. Day/Night Setback	11,900	42.8	0.3	QRIP/ECIP
9. Optimal Start/Stop	70,852	6.65	2.3	PECIP/ECIP

4.1.1 Reduce Outside Air Intake

The existing HVAC system uses 100% outside air and cools or heats it to the required supply temperature. Installing a return air system with economizer controls would allow conditioned air to be recycled through the air handling units. This system would allow the use of outside air for cooling when the conditions permit, and it would reduce the amount of outside air intake when heating or cooling. This would reduce the amount of energy required to meet the cooling, heating, and humidification loads.

Due to the limited amount of chase area, it was determined that the best approach to this project would be to convert some of the existing exhaust ducts into return air ducts. The existing system is designed such that most areas are required by code to be exhausted on separate exhaust systems. The return air ducts from the roof exhaust fans will be routed across the low roof and down the outside wall to the area B mechanical room outside air openings. The

rooms requiring exhaust due to ETL 1110-3-344 "Interior Mechanical Design Conditions for Army and Air Force Medical Facilities" will be ducted to one of the remaining exhaust systems.

Current Construction Cost	SIR	Simple Payback	Annual Energy Savings	Annual Fuel Cost Savings
$393,335	1.77	8.4 yrs	7524 MBtu	$ 50,635

4.1.2 Run Around Loop Heat Recovery System

The existing system exhausts the conditioned air to the outside and cools or heats the outside air to achieve the required supply air conditions. A run around loop could be used to recover the energy (heating or cooling) that is lost as the conditioned air is exhausted. This would reduce the amount of energy required to meet the cooling and heating loads.

The run around loop heat recovery system consists of cooling/heating coils installed in selected exhaust ducts and piped to cooling/heating coils in the supply air duct. When the control system indicates that the exhaust air temperature is higher (when heating) or lower (when cooling) than the outside air, the system is activated. Water is circulated through the coils which preconditions the outside air. Due to the static pressure drop across the coils, larger motors must be installed for the supply and exhaust system fans.

Current Construction Cost	SIR	Simple Payback	Annual Energy Savings	Annual Fuel Cost Savings
$83,585	1.86	10.8 yrs	2576 MBtu	$ 16,426

4.1.3 Replace Absorption Chiller with Electric Centrifugal Chiller

The existing system uses an 18,000 lb/hr, 100 psig steam boiler to drive a 536 ton absorption chiller to produce chilled water. An absorption chiller is an inefficient aethod of cooling (COP = 0.62); replacing it with an efficient electric centrifugal unit (COP = 4.5) saves energy and money.

Removing the absorption chiller's steam load greatly reduces the load on the large existing boiler during the summer. A 6900 lb/hr, 60 psig steam boiler is recommended to meet the cooling season steam requirements for reheat, sterilizers, kitchen equipment and domestic hot water. The new boiler can be installed in the southwest mechanical room. This will greatly reduce the heat gain in the boiler room, thus allowing the elimination of cooling for this area and increasing energy savings.

Emergency cooling must be supplied to operating, delivery, nursery, cystoscopic and intensive care areas. To provide these areas with cooling during a local utility, power outage, a 70-ton grade-mounted, air-cooled, chilled water chiller is recommended. Cooling coils will be installed in the branch ducts that supply air to the "emergency areas". The emergency generator will have ample capacity to handle the new emergency chiller since the cooling tower fans (4 @ 20 hp each), condenser water pumps for the primary chiller (75 hp), and the chilled water circulating pump (50 hp) will not be needed and can be removed from the emergency generator circuit.

Current Construction Cost	SIR	Simple Payback	Annual Energy Savings	Annual Fuel Cost Savings
$417,371	2.09	7.1 yrs	16132 MBtu	$ 76,097

4.1.4 Replace Boiler Economizer

The existing economizer, which serves both boilers, was installed as a retrofit item subsequent to initial construction. The economizer has failed in service, allegedly due to corrosion caused by low inlet feedwater temperature. The records of the installation necessary to permit the manufacturer to determine the original equipment performance and the potential cost of repair have not been located. However, cost estimates for and energy analyses have been performed to evaluate the cost-effectiveness of a complete replacement of the existing economizer.

Current Construction Cost	SIR	Simple Payback	Annual Enery Savings	Annual Fuel Cost Savings
$57,698	2.99	4.7 yrs	2231 MBtu	$12,404

4.1.5 Replace Standard Motors with Efficient Models

There are approximately 60 integral horsepower standard efficiency motors in use at the hospital. These motors have been in service about 13 years except for a few replacements. The motor sizes vary between one and 15 horsepower with most in the 5 to 7½ HP range. The motors have a normal life expectancy of approximately 20 years. This analysis investigates the cost and energy savings possible by replacing these standard motors with new high efficiency motors.

Of these motors studied, only the ones that operate continuously can be recommended for replacement. This amounts to 34 motors that are used to power air handlers, exhaust fans, supply fans, and water pumps. The following is a list of sizes and amounts.

Size (HP)	Amount
1	4
1½	3
2	1
3	5
5	1
7½	3
10	9
15	4
20	4
	34

Current Construction Cost	SIR	Simple Payback	Annual Energy Savings	Annual Fuel Cost Savings
$33,502	1.22	7.0 yrs	1449 MBtu	$ 3,397

4.1.6 Install Roll-Up Door Threshold Weatherstripping

The vehicle storage area of the Cutler Army Hospital has four metal roll-up doors. There is a 1 to 2-inch gap at the door threshold where existing weatherstripping has deteriorated. This area is heated so that the vehicles can be started immediately for emergencies. The project analyzed here is install new threshold weatherstripping to reduce the infiltration of air during the heating season. The recommended threshold seal is a rubber strip attached to an extended clear aluminum binder.

Current Construction Cost	SIR	Simple Payback	Annual Energy Savings	Annual Fuel Cost Savings
$464	2.98	1.75	48 MBtu	$ 267

4.1.7 Reduce Supply Air Volume

Currently the total amount of supply air circulated throughout the hospital is higher than required by ETL 1110-3-344 and 4270.1 M. Reducing the supply air volume, which is circulated 24 hours per day, 365 days per year, can provide significant energy savings.

Current Construction Cost	SIR	Simple Payback	Annual Energy Savings	Annual Fuel Cost Savings
$49,730	6.30	2.2 yrs	4624 MBtu	$23,027

4.1.8 Day/Night Setback

The energy required for heating or cooling during unoccupied hours is reduced by lowering the heating space temperature set point or raising the cooling space temperature setpoint. For areas that are not utilized 24 hours a day,

space temperature can be reduced from the normal winter inside design temperature to a lower space temperature during the unoccupied hours. In spaces that do not require air conditioning during unoccupied hours, the normal temperature setting is reset upwards to a temperature that is compatible with the special requirements.

Current Construction Cost	SIR	Simple Payback	Annual Energy Savings	Annual Fuel Cost Savings
$11,924	42.8	0.3 yrs	6945 MBtu	$37,043

4.1.9 Optimal Start/Stop

The day/night setback program function described in the previous subsection is refined by automatically adjusting the equipment operating schedule in accordance with space temperature, outside air temperature and humidity. In the scheduled temperature setback program, HVAC systems are restarted prior to occupancy to cool down or heat up the space on a fixed schedule independent of outside air and space conditions. The optimum temperature setback program automatically resets zone temperatures on a sliding schedule. The program will adjust restart times by taking into account the thermal inertia of the structure, the capacity of the HVAC system to either increase or reduce space temperatures, and outside air conditions, current space temperatures, using the predictor-corrector technique. This accurately determines the minimum time of HVAC system operation needed to satisfy the space environmental requirements at the start of the occupied cycle.

This function cannot be implemented using a local controller. Therefore, costs given here include the EMCS.

Current Construction Cost	SIR	Simple Payback	Annual Energy Savings	Annual Fuel Cost Savings
$70,852	6.65	2.3 yrs	7274 MBtu	$38,814

4.2 NON-QUALIFYING ECO's - Hospital

Six ECO's were judged to warrant detailed analysis but failed to achieve an SIR greater than one. These are listed in Table 4-2 and described in the following subsections.

TABLE 4-2 NON-QUALIFYING ECO's - Hospital

ECO's	Current Construction Cost	SIR	Payback (yrs)
1. Replace Incandescents	7,900	0.84	5.2
2. Install Dbl. Pane Window	$ 89,400	0.35	40.3
3a. Add Roof Insulation	200,700	0.14	98.5
3b. Add Wall Insulation	258,800	0.19	74.0
4. Reduce Pumping Flow	22,727	0.74	13.6
5. Reheat Coil Reset	102,333	0.40	35.3

4.2.1 Replace Incandescents with Fluorescent Fixtures

The basement and first floor of the hospital have fluorescent lighting throughout except for a few seldom used incandescent lights in the operating rooms, closets, etc. The second and third ward floors have a mixture of fluorescent and incandescent lighting with a total of approximately 200 incandescent lamps of 60 watts average rating each. This report investigates the cost and energy savings possible by replacing these incandescent lamps with fluorescent fixtures. The new screw-in type fluorescents were not evaluated because they could not fit in the existing incandescent fixture.

Current Construction Cost	SIR	Simple Payback	Annual Energy Savings	Annual Fuel Cost Savings
$ 7,934	0.84	5.16 yrs	381 MBtu	$ 812

4.2.2 Install Double-Pane Windows

The Cutler Army Hospital has 120 single-pane windows. All but four of these are a reversible type that allows for ease in cleaning. Since this type of window pivots on a vertical axis about the window centerline, additional glazing, such as storm windows, cannot be considered. New double-pane replacements are evaluated.

Current Construction Cost	SIR	Simple Payback	Annual Energy Savings	Annual Fuel Cost Savings
$89,394	0.35	40.3 yrs	419 MBtu	$ 2,237

4.2.3 Additional Insulation

The Cutler Army Hospital is a three story structure. The walls are concrete block covered with red face brick. The interior walls are covered with gypsum board. Existing walls have no insulation. The roof is a flat, built-up construction with one inch of insulation. The wall and roof U-values are 0.275 and 0.10, respectively.

To reduce project expense and the amount of interference with the hospital operations, only an exterior wall insulation was considered. The system studied is a "Dryvit" type so that it is functional, but asthetically unobjectionable. A foam insulation was considered for the roof, also because of its ease of implementation. The minimum level of insulation was added to bring the building up to DOD requirements. These are U = 0.10 for the walls and U = 0.05 for the roof.

Current Construction Cost	SIR	Annual Energy Savings	Annual Fuel Cost Savings
(Roof) $200,691	0.14	378 MBtu	$ 2,054
(Walls)$258,759	0.19	646 MBtu	$ 3,523

4.2.4 Reduce Pumping Flow

There are three major energy-using pumps in the hospital - a 40 hp chilled water pump, a 3 hp hot water pump and a 3 hp chilled/hot water pump. The chilled water pump operates for about 4 months a year, the hot water pump for about 8 and the chilled/hot water pump all year long. Each of these pumps are designed to operate at a constant speed based on peak space load requirements. Energy can be saved by reducing these pumped flow rates during off-peak hours. This can be accomplished by installing a frequency controller on the existing pump motors.

Current Construction Cost	SIR	Simple Payback	Annual Energy Savings	Annual Fuel Cost Savings
$22,727	0.74	13.6 yrs	792 MBtu	$1,687

4.2.5 Reheat Coil Reset Function

Terminal reheat systems operate with a constant chilled supply air temperature. Air supplied at temperatures below the individual space temperature requirements is elevated in temperature by reheat coil reset program to signals from

an individual space thermostat. The reheat coil reset program selects the reheat coil with the lowest discharge temperature or the reheat coil valve nearest closed (the zone with the least amount of reheat required) and resets the cold deck discharge coil with the lowest demand. Where humidity control is required, the program will prevent the cooling coil discharge temperature from being set upward when the maximum allowable humidity is reached.

Inspection of the Cutler Army Hospital revealed that there were nine HVAC zones and 120 terminal reheating units. If supply air temperature to each zone were increased slightly during times of moderate load conditions, the amount of energy required to cool the supply area and the amount of energy required to reheat the air at the terminal reheat units would be reduced.

Current Construction Cost	SIR	Simple Payback	Annual Energy Savings	Annual Fuel Cost Savings
$102,333	0.40	35.3 yrs	529 MBtu	$ 2,921

4.3 QUALIFYING ECO's - ASSOCIATED FACILITIES

Seven ECO's were identified as having SIR's greater than one. These are summarized in Table 4-3 and described in the following subsections.

TABLE 4.3 QUALIFYING ECO's - ASSOCIATED FACILITIES

	ECO's	ENERGY SAVINGS (MBtu/yr)	CONST COST ($)	SIR
1	Night Setback Controls - VDC	1,107	9,169	5.41
2	Night Setback Controls - OHC	156	6,323	2.08
3	Furnace Baffles - OHC	84	805	8.66
4	Reduce Lighting - VDC	278	2,075	3.77
5	Ceiling Insulation - OHC	19	733	2.10
6	Vacuum Pump Control Modification - VDC	75	858	2.46
7	Replace Water Heater - OHC	12	855	2.19

4.3.1 Install Night Setback Controls in the Vail Dental Clinic

The Vail Dental Clinic is occupied by staff and patients 45 hours per week. Significant energy can be saved by reducing heating and cooling levels during the remaining 123 hours each week.

Installation of night setback controls would reduce the consumption of electricity by 694 MBtu and the consumption of No. 2 oil by 413 MBtu annually. The construction cost of implementing the ECO is $9,169, yielding a total investment cost of $9,242. The discounted savings investment ratio is 5.41.

4.3.2 Install Night Setback Controls in the Oral Health Center

The Oral Health Center is occupied by staff and patients 45 hours per week. Significant energy can be saved by reducing heating and cooling levels during the remaining 123 hours each week.

Installation of night setback controls would reduce the consumption of electricity by 1 MBtu and the consumption of No. 2 oil by 155 MBtu annually. The construction cost of implementing the project is $6,323, yielding a total investment cost of $6,374. The discounted savings investment ratio is 2.08.

4.3.3 Install Baffles, Clean and Adjust Furnace in the Oral Health Center

Current efficiency of the furnace in the Oral Health Center is less than 65 percent. Installation of baffles, cleaning and adjusting air ratio in the combustion chamber will improve efficiency. These improvements will bring the boiler efficiency up to 77.25 percent.

If the boiler had operated at 77.25 percent efficiency for the past two heating seasons instead of its 64.75 percent efficiency, the following average yearly savings would have been realized:

Fuel Oil	82 MBtu	$ 615
Electricity	2 MBtu	$ 4
Total	84 MBtu	$ 619

Based upon a 15 year life, the total discounted savings is $7029. The total investment associated with implementing the recommended items is $811. Discounted savings investment ratio is 8.66.

4.3.4 Reduce Lighting Levels in the Vail Dental Clinic

Light levels in offices and treatment rooms of the Vail Dental Clinic were measured at 180 foot candles. This measurement was made with the task lamps off. Required lighting levels for offices and treatment rooms is specified in DOD 4270.1 as being 50 foot candles. Removal of some of the fluorescent bulbs and ballasts in each room will save electric power while still maintaining adequate lighting levels.

If the project were implemented, electrical demand would be reduced by 10.64 KW. Electric energy consumption would be reduced 23,940 KWH (278 MBtu) per year. Construction cost for implementing the project is estimated to be $2075 if done with contract labor. The discounted savings investment ratio, when non-energy savings credit is limited to 25 percent of the total, is 3.77.

4.3.5 Add Ceiling Insulation in the Oral Health Center

Adding batt insulation above the ceiling in the Oral Health Center will reduce energy required to maintain desired inside temperatures. The existing U value is 0.069. Adding 3½ inches of additional batt would increase the U value to 0.039 Btu/hr ft^2 F.

Analysis of building energy consumption showed that adding ceiling insulation would reduce the consumption of No. 2 oil by 18 MBtu annually. The construction cost of implementing the project is $733, yielding a total investment of $739. The discounted savings investment ratio is 2.10.

4.3.6 Modify Vacuum Pump Control in the Vail Dental Clinic

Two 10 horsepower pumps are currently run to provide vacuum for mouth suction in the Vail Dental Clinic. The pumps are sized so that either would provide the required suction capacity. A control modification will permit only one pump to operate at a time with alternating between the pumps.

Operating the oral evacuation system in the manner recommended would save 75 MBtu per year. Total construction cost of providing the modified controls is $858. The discounted savings investment ratio, when non-energy savings credit is limited to 25 percent of the total, is 2.46.

4.3.7 Replace Domestic Water Heater (DWH) in the Oral Health Center

The Oral Health Center is housed in a building that originally served as a barracks. The oil fired DWH is sized for that use. Replacement with a small electric water heater would provide adequate capacity for current needs and reduce storage losses.

Projected annual energy savings are 12 MBtu. The total construction cost of implementing the ECO is $855. The discounted savings investment ratio is 2.19.

4.4 NON-QUALIFYING ECO's - ASSOCIATED FACILITIES

Seven ECO's were judged to warrent detailed analysis but failed to achieve an SIR greater than one. These are listed in Table 4-4 and described in the following subsections.

TABLE 4-4 NON-QUALIFYING ECO's - ASSOCIATED FACILITIES

	ECO's	Energy Saved (MBtu/Yr)	Construction Cost ($)	SIR
1.	Deck Temperature Reset - VDC	1	2017	0.01
2.	Outside Air for Cooling - VDC	7	11588	0.01
3.	AHU Motor Replacement - VDC	13	2283	0.16
4.	Install Storm Windows - VDC	89	7419	0.91
5.	Add Roof Insulation - VDC	27	16324	0.12
6a.	EMCS (Setback) - VDC	1107	175906	Neg.
6b.	EMCS (Optimal s/s) - VDC	1120	182345	Neg.
7a.	EMCS (Setback) - OHC	156	174781	Neg.
7b.	EMCS (Optimal s/s) - OHC	174	181217	Neg.

4.4.1 Reset Hot and Cold Deck Temperatures in the Vail Dental Clinic

The HVAC unit in the Vail Dental Clinic is a dual duct multizone system. A discriminator to reset the cooling coil temperature during periods of partial loads would permit temperatures of the chilling water to be increased. This may improve system efficiency.

Analysis of building energy consumption showed that reset of hot and cold deck temperatures would not meaningfully reduce the consumption of electrical source energy or fuel oil consumption. The construction cost of implementing the ECO is $2,017, yielding a total investment cost of $2033. The discounted savings investment ratio is 0.01.

4.4.2 Use Outside Air for Cooling in the Vail Dental Clinic

Installation of economizer controls in the Vail Dental Clinic would permit regulation of outside air and return air quantities entering the air handling unit. This allows the use of outside air for cooling when conditions permit, and reduces the amount of outside air intake when it must be heated or cooled.

Analysis of building energy consumption showed that use of outside air for cooling would reduce the consumption of electrical source energy by 7 MBtu annually. The construction cost of implementing the ECO is $11,588, yielding a total investment cost of $11,681. The discounted savings investment ratio is 0.01.

4.4.3 Install Minimum Size High Efficiency Motor in AHU of the Vail Dental Clinic

Cleaning and balancing of the air duct system in the Vail Dental Clinic is recommended in Section 4.1 of Volume 3. With static pressure and air quantity reset at design levels, the AHU should require only a 10 horsepower motor. The AHU presently has a 15 horsepower motor.

If the ECO was implemented and a high efficiency motor was installed, motor efficiency would be increased from 86 to 90 percent. Electrical demand would be reduced by approximately 0.24 KW. Electric energy consumption would be reduced 1,100 KWH (13 MBtu source energy) per year. Direct construction cost of implementing the project is estimated to be $2265 if done with contract labor. Total investment cost is $2283. The discounted savings investment ratio, when non-energy savings credit is limited to 25 percent of the total, is 0.16.

4.4.4 Install Storm Windows in the Vail Dental Clinic

Windows in the Vail Dental Clinic are fixed single pane units. Installation of a storm window (a second pane) will reduce energy required to maintain desired inside temperature.

Analysis of building energy consumption showed that the installation of storm windows would reduce the consumption of No. 2 oil by 77 MBtu annually and the consumption of electrical source energy by 12 MBtu annually. The construction cost of implementing the project is $7419, yielding a total investment cost of $7478. The discounted savings investment ratio is 0.93.

4.4.5 Add Roof Insulation in the Vail Dental Clinic

The roof of the Vail Dental Clinic is nearing its end of life. Adding additional insulation when the roof is replaced will reduce energy required to maintain desired inside temperatures. The "R" value for the existing roof (including inner and outer air films) is 15.3 (U = 0.069). Adding two inches of polyurethane insulation will increase this "R" value by 14.3 (U = 0.034 Btu/ft^2 hr °F).

Analysis of building energy consumption showed that adding additional roof insulation when the roof is replaced would reduce the consumption of No. 2 oil by 23 MBtu and reduce the consumption of electrical source energy by 4 MBtu annually. The incremental construction cost of installing additional insulation when the roof is replaced is $16,324. This does not include the estimated cost of $35,000 for normal roof replacement. Total investment cost is $16,455. The discounted savings investment ratio is 0.13.

4.4.6 Install EMCS in the Vail Dental Clinic

An EMCS in the Vail Dental Clinic could save energy by providing dynamic intelligent control of the HVAC and by providing for optimal night setback of the heating and cooling temperatures.

Installation of an EMCS to implement day/night temperature setback reduces the consumption of electricity by 694 MBtu and the consumption of No. 2 oil by 413 MBtu annually. The construction cost of implementing the project is $175,906, yielding a total investment cost of $177,313. Annual maintenance cost, estimated to be ten percent of the construction cost, is $17,591. The resulting discounted savings investment ratio is negative.

Installation of an EMCS to implement optimal start/stop for the temperature setback period would reduce the consumption of electricity by 684 MBtu and the consumption of No. 2 oil by 436 MBtu annually. The construction cost of implementing the project is $182,345, yielding a total investment cost of $183,804. Annual maintenance cost, estimated to be ten percent of the construction cost, is $18,234. The resulting discounted savings investment ratio is negative.

4.4.7 Install EMCS in the Oral Health Center

An EMCS in the Oral Health Center could save energy by providing for optimal night setback of the heating and cooling temperatures.

Installation of an EMCS to control night setback would reduce the consumption of electricity by 1 MBtu and the consumption of No. 2 oil by 155 MBtu annually. The construction cost of implementing the project is $174,781, yielding a total investment cost of $176,179. Annual maintenance cost, estimated to be ten percent of the construction cost, is $17,478. The resulting discounted savings investment ratio is negative.

Installation of an EMCS to provide optimal start/stop of the temperature setback period would reduce the consumption of electricity by 3 MBtu and the consumption of No. 2 oil by 171 MBtu annually. The construction cost of implementing the project is $181,217, yielding a total investment cost of $182,667. Annual maintenance cost, estimated to be ten percent of the construction cost, is $18,122. The resulting discounted savings investment ratio is negative.

4.5 INAPPLICABLE ECO's- HOSPITAL

Table 4-5 contains a list of all ECO's that were judged not to warrant a detailed analysis.

TABLE 4-5 INAPPLICABLE ECO's - HOSPITAL

CATEGORY	DESCRIPTION	COMMENTS
HVAC	1. Shut off or reduce speed of room fan coil	Existing controls are manually operated for patient comfort.
	2. Shut off unneeded circulating pumps	There are none.
	3. Reduce humidification to minimum requirements	Humidifier controls are currently being maintenanced to accomplish this.
	4. Reduce condenser water temperature	Not applicable for absorption chiller.
	5. Repair and maintain steam lines and steam traps	There are no major repairs needed.
	6. Use damper controls to shut off air to unoccupied areas	There are no unoccupied areas of significant size.
	7. Raise chilled water temperature	Already manually done.
	8. Shed loads during peak electrical use periods	No significant loads can be shed.
	9. Use outside air for free cooling whenever possible	100% OSA system. Added to reduce OSA ECO.
	10. Reduce chilled water circulation during light cooling loads	Not applicable because of current manual chilled water temperature reset practice.
	11. Install minimum sized motors	No motors found to be greatly oversized.
	12. Replace hand valves with automatic controls	No opportunities exist.

TABLE 4-5 Continued

CATEGORY	DESCRIPTION	COMMENTS
HVAC, continued	13. Install variable air volume controls	All air handling units have areas that require minimum amounts of supply air.
	14. Insulate ducts and piping	No major inadequacies.
	15. Eliminate Simultaneous heating and cooling	Analyzed in Reheat Coil Reset ECO.
	16. Clean coils and tubes	Most appears okay, currently maintained under contract.
	17. Maintain air filters	Filters are clean.
Boiler Plant	1. Reduce steam distribution pressure	Already done.
	2. Shut off steam to laundry when not in use	No laundry.
	3. Increase boiler efficiency	Current efficiency is at acceptable level-78%.
	4. Repair, replace or install condensate return system	Most are in satisfactory condition
	5. Insulate boiler piping	Adequate insulation exists.
	6. Install air preheater	Economizer for preheating feedwater is more cost effective.
	7. Check boiler water chemistry program	Adequate program boiler water treatment program is currently handled by company specializing in such.
	8. Clean boiler tubes	Part of maintenance program and contracted.

TABLE 4-5 Continued

CATEGORY	DESCRIPTION	COMMENTS
Lighting	1. Shut off lights when not needed	Already done.
	2. Reduce lighting levels	Already done.
	3. Revise cleaning schedules	Not applicable.
Building Envelope	1. Install solar shading or screening	Already done.
	2. Install additional walls to contain air-handling room	Already exists.
Electrical Equipment	1. Shut off elevators whenever possible	Already done.
	2. Shut off pnematic tube system whenever possible	None exists.
	3. Install capacitors or synchronous motors	No power factor penalty charged.
	4. Shed or cycle electrical loads to reduce peak demand	The nature of hospital operations precludes cycling or shedding of electrical loads
	5. Balance loads	Imbalance is insignificant.
	6. Reduce transformer losses by proper loading and balancing	Transformer is properly loaded and balanced.
Plumbing	1. Repair and maintain hot water steam piping insu-insulation.	No significant defective insulation found.
	2. Install flow restrictors	Flow rates are already at low volume.
	3. Install faucets which automatically shut off water flow	There are no high use lavatories.
	4. Decentralize hot water heating	Hot water use is too widely distributed throughout the hospital.
	5. Add piping insulation	Adequate piping insulation exists

TABLE 4-5 Continued

CATEGORY		DESCRIPTION	COMMENTS
Laundry			There is no laundry.
Kitchen	1.	Install high-efficiency steam control valves	Existing valves operate satisfactorily.
	2.	Shut off equipment and appliances whenever possible	Already done.
	3.	Install heat reclaimation system for exhaust heat.	Heat recovery from range exhaust hoods is being investigated as part of Run Around Loop Heat Recovery ECO.
	4.	Install nighttime automatic steam cut-off	Already done manually at kitchen. Steam line runs between kitchen and boiler room are short.
Miscellaneous	1.	Install incinerator and heat recovery system	Incinerator already exists. It's small capacity makes heat recovery impractical.

4.6 INAPPLICABLE ECO's - ASSOCIATED FACILITIES

Table 4-6 contains a list of all ECO's that were judged not to warrant a detailed analysis.

Table 4-6 Inapplicable ECO's - Associated Facilities

CATEGORY	DESCRIPTION	COMMENTS
HVAC	1. Reduce outside air intake when air must be heated or cooled before use.	The OHC has no mechanically-supplied OSA. The VDC OSA intake is below ETL 1110-3-344 minimums.
	2. Reduce volume of air circulated through AHU's.	Supply air volumes are within 10% of Army guidelines.
	3. Shut off or reduce speed of room fan coil units.	There are no fan coil units.
	4. Shut off unneeded circulating pumps.	There are no unneeded circulating pumps.
	5. Reduce humidification to minimum requirements.	No humidification is provided.
	6. Reduce condenser water temperature.	No condenser water exists.
	7. Repair and maintain steam lines and steam traps.	There are no major repairs needed.
	8. Use damper controls to shut off air to unoccupied areas.	There are no unoccupied areas.
	9. Shed loads during peak electrical use periods.	No significant loads can be shed.
	10. Reduce reheating of cooled air.	There is no reheating of cooled air.
	11. Recover heating or cooling with energy recovery units.	No significant opportunities exist.
	12. Replace hand valves with automatic controls.	No opportunities exist.

Table 4-6 - Continued

CATEGORY	DESCRIPTION	COMMENTS
	13. Install variable air volume controls.	Existing supply air rates are at minimums.
	14. Insulate ducts and piping.	No major inadequacies.
	15. Eliminate simultaneous heating and cooling.	None exists.
Boiler Plant	1. Reduce steam distribution pressure.	Already done.
	2. Shut off steam to laundry when not in use.	No laundry.
	3. Insulate boiler piping.	Adequate insulation exists.
	4. Install boiler economizer.	Not feasible on small system (19 HP)
	5. Install air preheater.	Not feasible on small system (19 HP)
	6. Eliminate air conditioning in the boiler room.	None exists.
Lighting	1. Shut off lights when not needed.	Already done.
	2. Revise cleaning schedules	Heating and cooling hours are not extended for cleaning personnel.
Building Envelope	1. Reduce infiltration by caulking and weather-stripping.	No significant inadequacies exist.
	2. Install loading dock door seals.	No loading dock doors exist.
	3. Install solar shading or screening.	Already exist.
	4. Install additional walls to contain air-handling room.	Already exist.
Electrical Equipment	1. Shut off elevators whenever possible.	None exist.

Table 4-6 - Continued

CATEGORY	DESCRIPTION	COMMENTS
	2. Shut off pneumatic tube system whenever possible.	None exists.
	3. Install capacitors or synchronous motors.	No power factor penalty is charged.
	4. Shed or cycle electrical loads to reduce peak demand.	No shedable loads.
	5. Balance loads	Imbalance is significant.
	6. Reduce transformer losses by proper loading and balancing.	Transformer's properly loaded and balanced.
Plumbing	1. Install flow restrictors	No high use showers or faucets exist.
	2. Install faucets which automatically shut off water flow.	No high use faucets exist.
	3. Decentralize hot water heating.	These buildings are small and piping runs are short.
Laundry		There is no laundry.
Kitchen		There is no kitchen.
Lab and Operating Rooms	1. Humidity and temperature control.	No problem exists.
Miscellaneous	1. Install incinerator and heat recovery system.	Waste generation capacity is well under the required 2 tons per hour for heat recovery (TM 5-838-2).

4.7 SOLAR APPLICATIONS

Practical uses for solar energy within the Cutler Army Community Hospital and the Associated Facilities were investigated. Production of domestic hot water was determined to be the most feasible application of solar energy, because of the need for low temperature (105 degrees Fahrenheit) water in both of the buildings.

Results of a previous Solar Application study* for Seneca Army Depot (Seneca, New York) apply directly to the selected solar applications at Ft. Devens. In the Seneca study, three barrack buildings were identified as promising candidates for solar applications. All three buildings contained administrative offices and enlisted men's quarters. Each buildings required a continuous supply of low temperature hot water. This requirement for hot water was the main reason for the summer time operation of a central boiler plant. Use of solar energy would save 3270 MBtu per year of fossil energy and would permit the central boiler operation to be discontinued during the summer. This would result in the reassignment of 2848 man-hours previously charged to energy production.

Economic analysis showed that a flat plate solar collector producing 110 degree Fahrenheit water did not meet ECIP criteria of having a discounted savings investment ratio greater than one. Thus, the life cycle cost of utilizing solar energy exceeded the life cycle cost of continuing to use existing fossil fuel based methods for providing domestic water heating.

The Seneca Army Depot solar application project had the benefit of allowing the central boiler to be shut down during summer months, thereby eliminating boiler operator man-hours for the entire summer. This advantage could not be realized at any of the Fort Devens facilities, as the domestic water heating units therein are automatically controlled unmanned devices. Tempered by the results of the Seneca study, it is evident that the application of solar energy for the associated health facilities at Fort Devens is not economically feasible.

* Increment C, "Seneca Army Depot", Energy Engineering Analysis Program, November 1983, Contract No. DACA 65-80-C-0003

4.8 ENERGY SAVING OPERATION AND MAINTENANCE RECOMMENDATIONS

4.8.1 Cutler Army Community Hospital

Heating, Ventilating and Air Conditioning

Repair defective duct access doors to reduce infiltration and exfiltration loads.

Repair or replace damaged insulation in basement.

Close holes around piping in the re-coiled air handling units. HV-1A Access doors will not close and piping needs to be re-insulated. HV-1B Piping needs to be re-insulated.

AC-1 - After filter access doors will not close, and upstream flexible connection has an opening.

AC-5 - Large openings around chilled water pipe penetrations through AHU casing should be closed and afterfilter access panels aligned to provide airtight closure.

AC-6 - After filter access doors should be aligned and steam piping reinsulated.

AC-8 - Same as AC-5. Condition may warrant replacement of this unit.

REF-2 & REF-3 - Top cap of these fans is not secure and should be repaired or replaced.

Manual steam valves for stairwell convectors can be adjusted to lower temperatures in stairwells to 50°F.

Lighting and Electrical Equipment

No schedule of lighting fixture and lamp cleaning is used in the hospital at present. A program of regular cleaning could increase the illumination 10% to 20%. However, it appears doubtful that the improved lighting levels will be significantly above the required ranges of illumination in most areas of the hospital. It will mean that more energy is converted to useful light.

The 10 HP air compressor for the pneumatic heat control system is running approximately 50% of the time. This indicates leakage in the system.

Plumbing

Water was found leaking from the two domestic water storage tanks located in the basement. The leaks were not major, but are a source of energy waste.

Building Envelope

All personnel door openings to the outside need new weatherstripping. This can be handled through the Self-Help Store on Post.

Many windows/frames have been taped on the building exterior indicating possible problems. Examination of the windows from the interior showed them to be well-fitting although gaskets were deteriorating. Since the window seals with the existing frame, it is recommended that no work should be done on the gaskets until windows are needed to be replaced for other reasons.

4.8.2 Associated Facilities

Restore Air Balance in the Vail Dental Clinic

Due to lint buildup in the return air system, ductwork cleaning should be done before the air balance is restored. With static pressure and air quantity reset to desired levels, the air handling unit power requirements shoudl be reduced approximately 5 horsepower. Based upon present usage, this represents a reduction of 441 MBtu of electric source energy. This energy savings is worth $932 per year. The savings from lower demand charges is $527 per year.

Modify Outside Air Louver in the Vail Dental Clinic

During the inspection, the outside air louver had large leaves trapped between it and its bird screen. Relocating the bird screen to the front of the louver would eliminate this situation. A modest reduction in use of electrical source energy would be realized by reducing the suction pressure on the AHU fan. The major benefit would be to assure the proper mix of outside and return air to the AHU.

Add Additional Outside Air Louver in the Vail Dental Clinic

The existing outside air supply louver serving the HVAC system has approximately 3 square feet of free area. With exhaust fans EF-2 and EF-3 operating, a slight negative pressure is created in the building. Energizing exhause fan EF-1 creates approximate 0.1" W.G. (water gauge) negative pressure inside the building and causes increased infiltration.

This situation could be relieved by installing a new 36" by 24" outside air louver to supply combustion air directly to the steam boiler. The existing combustion air intake could then be converted to a second outside air intake by the installation of new ductwork.

Correct Prosethetics Laboratory Exhaust and Return System in the Vail Dental Clinic

The prosthetics laboratory is served by exhaust fan EF-1 which is controlled by a wall switch. The wall switch also activates an isolation damper in the return air duct serving the laboratory. When the exhaust fan is energized, the damper opens when it should close. This condition should be corrected. The filters and register which have been removed should be replaced before air balance is restored.

Utilize Natural Gas As Boiler Fuel in the Vail Dental Clinic

Natural gas is currently less expensive per heating unit than No. 2 fuel oil. The boiler in Vail Dental Clinic now uses natural gas as an alternate fuel and could use natural gas as a primary fuel with no hardware changes.

As energy consumption is approximately the same regardless of what fuel is used, expected savings can be estimated based upon the difference in cost of supplying the energy with natural gas instead of No. 2 fuel oil. Cost of 1117 MBtu of No. 2 fuel oil is $8,378. Cost of 1117 MBtu of natural gas is $6,490. Savings from using natural gas as the primary fuel would be $1,888 per year.

Repair Air Handling Unit in the Oral Health Center

During the inspection a bent filter was noticed in the split system air handler. This condition permits unfiltered air to flow through the evaporator coil and to the conditioned space. Replacement of the filter would improve performance of the system. Exterior panels should be straightened at suction and liquid connections.

Repair Refrigerant Pipe Insulation in the Oral Health Center

The armaflex suction line insulation was deteriorating in the area between the condensing unit and exterior pipe chase. Installing new insulation with a corrugated aluminum shield is recommended in this exposed area.

Clean Soot from Furnaces in the Oral Health Center

Soot and carbon deposits on the boiler fuel passages and heating surfaces reduce heat transfer in the furnace and increase stack gas losses. The inside of the furnace should be cleaned and the air flow to the combustion chamber adjusted. Cleaning plus improvements recommended in Section 3.2.6 of Volume 3 could reduce energy consumption by the furnace in the OHC by 84 MBtu per year.

Insulate Hot Water Pipes in the Oral Health Center

Pipes carrying hot water from the domestic water heater in the OHC to the lavatories are not insulated. Because of the relatively short distance separating the two, insulation cost and resulting energy savings would not justify project development. The pipes should be insulated as part of operation and maintenance.

4.9 HEAT RECOVERY INCINERATOR UPDATE

If the ECO's recommended in this report are implemented at Cutler Army Hospital, previous projects recommended in the EEAP for Ft. Devens are re-evaluated. The only project that fits in this category is the Heat Recovery Incinerator, Project H, which was recommended as part of the EEAP, Increments A & B. This project is documented in "ECIP Project Descriptions, 1391's, and Back-Up Data, Volume 2, Fort Devens, Massachusetts".

In the original study three alternate applications were studied for the incinerator project - the hospital, building 3713 with incinerator in the existing boiler room, and building 3713 with the incinerator located in a separate building. The analysis has been reproduced and is included in the Narrative Report and Appendix C. Only those sections concerning the hospital have been revised and updated.

Conclusion

Although the project was recommended in the earlier report based on an E/C of 16.8, the results here indicate an SIR of 0.67. New projects recommended in this document reduce the hospital heating loads by at least 40%, and, therefore, much of the steam generated by the incinerator is no longer useful. Consequently, the incinerator cannot be recommended for funding.

Current Construction Cost	SIR	Annual Energy Savings	Annual Fuel Cost Savings
$1,632,070	0.67	13039 MBtu	$ 70,581

5.0 ENERGY PLAN

5.0 ENERGY PLAN

5.1 PROJECT LISTINGS

Two projects have been recommended for the Cutler Army Hospital. One, an OMA QRIP project, is "Replacement of Roll-Up Door Threshold Weatherstripping" in the vehicle storage area. The cost of this project is only $464 with a SIR equal to 2.98 and a payback of 1.75 years. The other is an ECIP - "HVAC Modifications". This project includes the following:

- Reduction of supply air volume
- Reduction of outside air volume
- AHU economizers
- Run around loop heat recovery
- High efficiency electric centrifugal chiller
- Boiler economizer
- High efficiency motors
- Day/night setback local controller

Energy savings for this ECIP were calculated using DOE-2 plus modifications. All features except "high efficiency electric motors" and "boiler economizer" were modeled using DOE-2. Savings for these two features were calculated by hand. Non-energy savings, also hand-calculated, include changes in electric demand for the high efficiency electric chiller, high efficiency electric motors, additional fans for the heat recovery and outside air volume reduction ECO's.

Table 5-1 lists projects by SIR.

TABLE 5-1 PROJECT GROUPING PRIORITIZED BY SIR - HOSPITAL

PROJECTS	TYPE	Current Construction Cost (1000's)	Annual Energy Savings (MBtu)	Annual Fuel Cost Savings (1000's)	Non Energy Savings (1000's)	SIR	* Simple Payback (Yrs)
THRESHOLD WEATHERSTRIPPING	OMA QRIP	$0.46	48	$0.267	0	2.98	1.75
HVAC MODIFICATION	ECIP	$1009.00	19,371	$126.80	-$23.045	1.59	9.8
TOTAL		$1009.46	19,419	$127.10			

* Simple payback is taken from the ECIP Life Cycle Cost Analysis Summary forms (see pages 1-13 and 1-50 in Vol. 4). It is defined there as Total Investment divided by first year savings.

Associated Facilities

Seven individual ECO's for the Associated Facilities were found to have SIR's greater than one. These were grouped into two qualifying projects described in Table 5.2. One combined project is to be submitted as a QRIP and the other to be submitted as a PECIP. The two combined projects will provide a yearly energy savings of 1,754 MBtu. First year savings total $9,163. Construction cost for the QRIP is $3,738. Construction cost for the PECIP project is $17,080. It is expected that the QRIP project will be implemented in 1986 and the PECIP project will be implemented in 1987.

TABLE 5.2 PROJECT GROUPING PRIORITIZED BY SIR - ASSOCIATED FACILITIES

PROJECT DESCRIPTION		SIR
QRIP FOR ASSOCIATED FACILITIES		5.14
Furnance baffles - OHC		
Reduce lighting - VDC		
Elec motor control - VDC		
Total energy saved	437 MBtu/yr	
Total construction cost	$3,738	
Non-energy savings (costs)	$1,606 per yr	
Simple payback period*	1.27 years	
PECIP FOR ASSOCIATED FACILITIES		3.71
Rep water heater - OHC		
Night setback - VDC		
Night setback - OHC		
Ceiling insulation - OHC		
Total energy saved	1,259 MBtu	
Total construction cost	$17,080	
Non-energy savings (costs)	($ 59 per yr)	
Simple payback period*	2.98 years	

* Simple payback is taken from ECIP Life Cycle Cost Analysis Summary forms (see pages 2-8 and 2-39 in Vol. 4). It is defined there as Total Investment divided by first year savings.

5.2 Schedule of Energy Conservation Projects

Table 5-3 below lists the projects recommended and the year in which each is scheduled to be implemented.

TABLE 5-3 ENERGY CONSERVATION PROJECTS SCHEDULE

PROJECT	TYPE	FISCAL YEAR
HVAC MODIFICATIONS - CAH	ECIP	1987
REPLACE ROLLUP DOOR THRESHOLD WEATHERSTRIPPING - CAH	OMA QRIP	1986
QRIP FOR ASSOCIATED FACILITIES	QRIP	1986
PECIP FOR ASSOCIATED FACILITIES	PECIP	1987

6.0 ENERGY AND COST SAVINGS

6.0 ENERGY AND COST SAVINGS

Cutler Army Hospital

Tables 6-1 and 6-2 contain the projected energy and non-energy savings, respectively, for the ECIP and the weatherstripping project. The non-energy savings are due to changes in peak electrical demand at the hospital. The electrical demand increase is caused by the addition of the electrical chiller.

Table 6-3 shows the energy use projects for the hospital if the two projects are implemented. Electricity use will increase by about 16% while fuel oil will decrease about 41%. This results in a total energy use reduction of 20%.

Additional savings can be realized if the hospital interior space temperatures are brought in line with Department of the Army Regulations AR 11-27 and TM 5-838-2. These savings are:

Electricity:	167 source MBtu or $356/yr
Fuel Oil:	6113 source MBtu or $33,988/yr

Figures 6-1, 6-1a and 6-2 show the projected energy use on costs for the hospital through FY 88 when all recommended projects are implemented. Fuel price projections are based on the U.S. Department of Energy's estimates. See Appendix C for back-up calculations (Energy Cost Projections).

Figure 6-1 depicts graphically those values contained in Table 6-3. Figure 6-1a describes the shift toward electricity becoming the U. S. Army's primary energy source in facility energy use. Savings on heating energy and replacement of absorption chiller with an electric centrifugal on are the primary reasons for this shift at the hospital. Figure 6-2 shows an estimated annual savings of $90,000 in FY 88 due to implementation of the projects recommended in this report. This represents a 20% reduction in annual energy costs.

Associated Facilities

Table 6-4 contains the energy and cost savings for the two projects. The non-energy savings (or additional costs) are caused by changes in base wide peak electrical demand occurring as a result of implementing the projects.

Figure 6-3 and 6-3a show the projected total energy consumption and breakdown by type for the Associated Facilities of the Cutler Army Hospital. The decrease in energy use between FY 87 and FY 88 reflects the savings achieved when the recommended projects are implemented. Projected energy costs are shown in Figure 6-4.

TABLE 6-1. PROJECT ENERGY SAVINGS - HOSPITAL

PROJECT	YEAR OF PROJECT	ENERGY SAVINGS (MBtu) ELECTRICITY	FUEL OIL
HVAC Modifications	1987	-5563	24,934
Roll-Up Door Threshold Weatherstripping	1986	-	48
TOTALS		-5563	24,982

TABLE 6-2. PROJECT NON-ENERGY SAVINGS - HOSPITAL

PROJECT	SAVINGS (1984$)
HVAC Modifications	$ -23,045
Roll-Up Door Threshold Weatherstripping	-
TOTAL	$ -23,045

TABLE 6-3. PROJECTED ENERGY USE (MBtu) - HOSPITAL

ENERGY TYPE	EXISTING* CONDITION	PROJECTS IMPLEMENTED
Electricity	33,756	39,319
Fuel Oil	61,170	36,188
TOTAL	94,926	75,507

* Three year average

FIGURE 6-1
PROJECTED ENERGY USE
CUTLER ARMY HOSPITAL

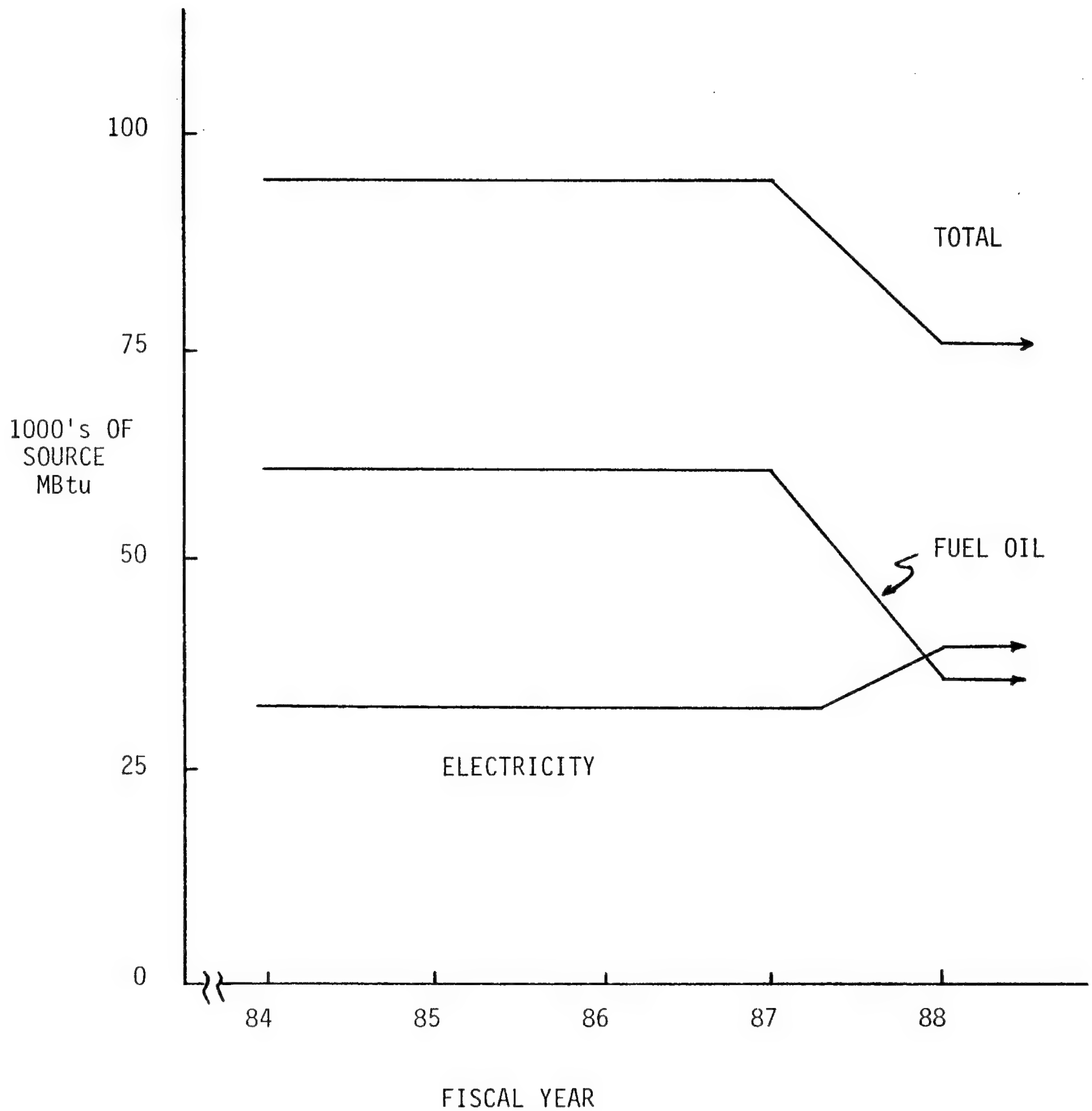
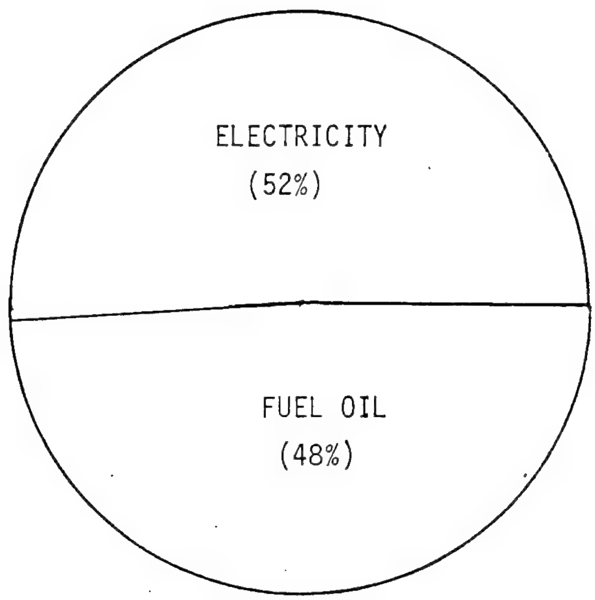


FIGURE 6-1a

CUTLER ARMY HOSPITAL
ENERGY USE BY TYPE - AFTER
PROJECT IMPLEMENTATION



TOTAL: 100% = 75,507 MBTU

FIGURE 6-2
PROJECTED ENERGY COSTS
CUTLER ARMY HOSPITAL

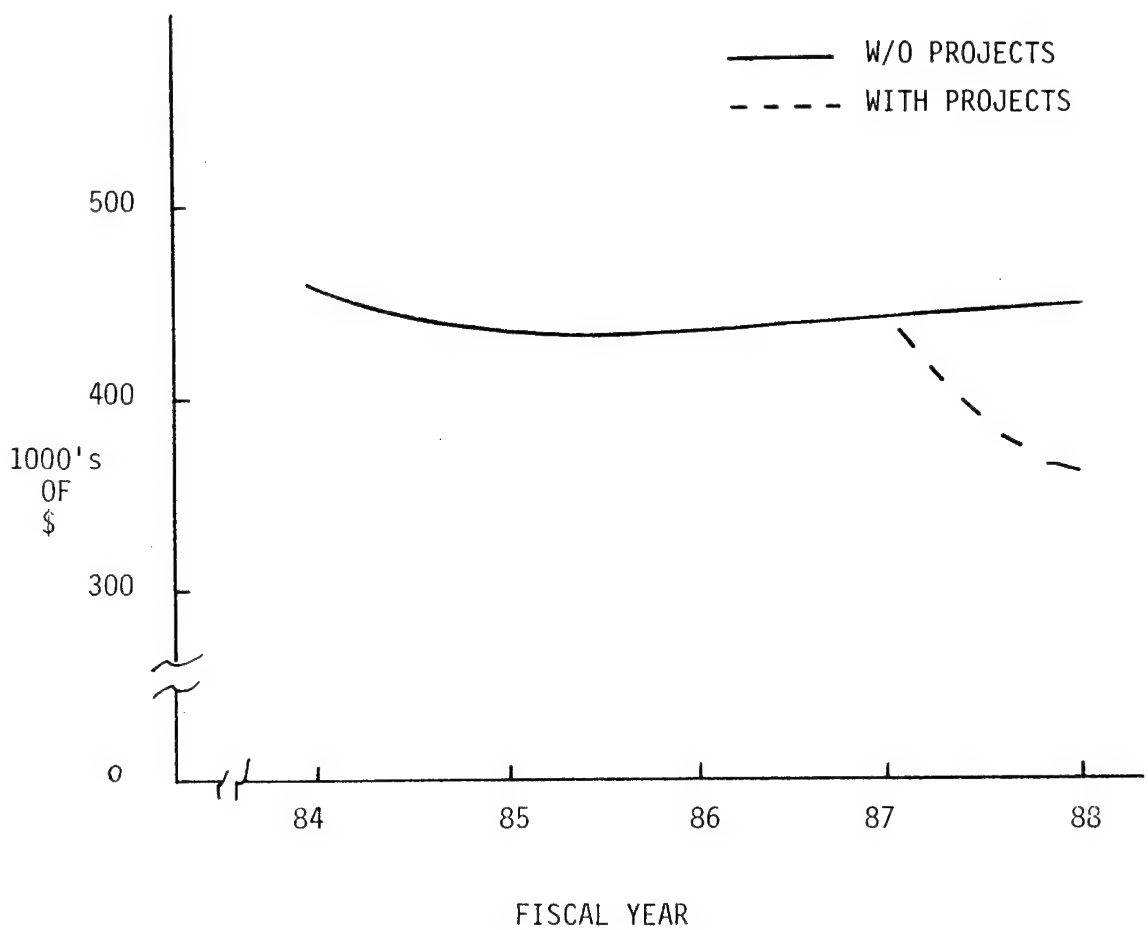


TABLE 6-4 PROJECTED ENERGY AND COST SAVINGS - ASSOCIATED FACILITIES

PROJECT DESCRIPTION	YEAR OF PROJECT	ENERGY SAVINGS (SOURCE MBTU)	
		ELECTRIC	FUEL OIL
COMBINED QRIP PROJECT	86	355	82
COMBINED PECIP PROJECT	87	670	589
All projects implemented		1025	671

NON-ENERGY SAVINGS (1984 $)	
COMBINED QRIP PROJECT	$1606 / year
COMBINED PECIP PROJECT	- $ 59 / year
Total	$1547 / year

FIRST YEAR ENERGY SAVINGS = $ 8763

Total first year savings = elec + oil + non energy
(1083 MBtu) * (2.13 $/MBtu) + (671 MBtu) * (7.50 $/MBtu) + $1547

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FIGURE 6-3 - PROJECTED ENERGY USE

ASSOCIATED FACILITIES

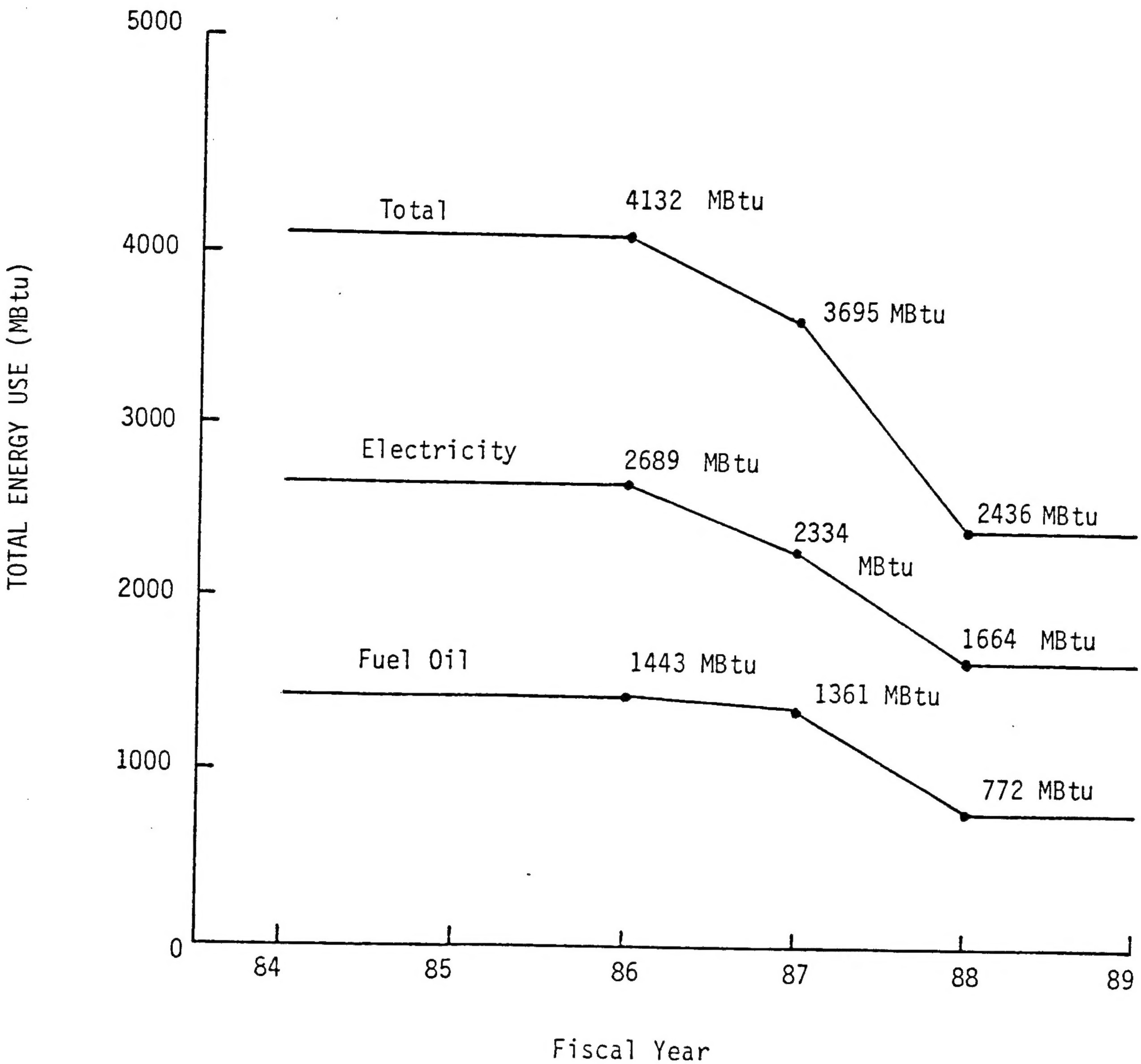
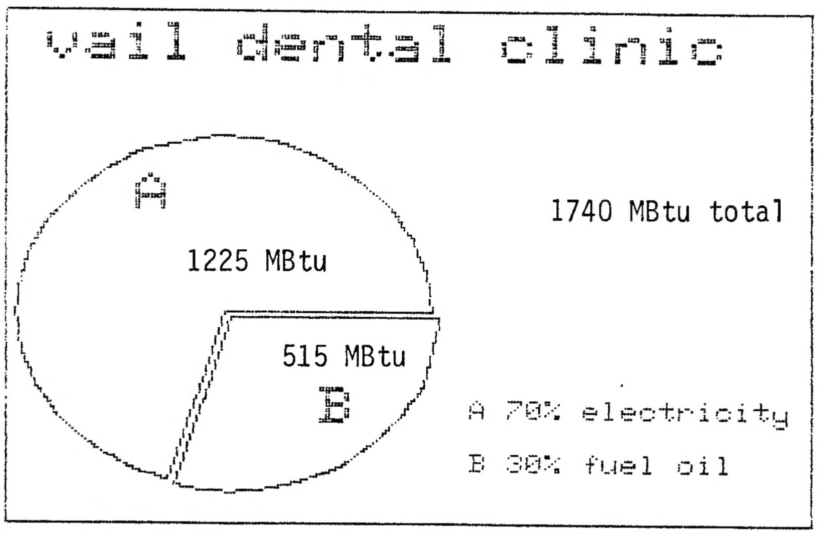


FIGURE 6-3A ENERGY USE BY TYPE
(After Implementation of Projects)



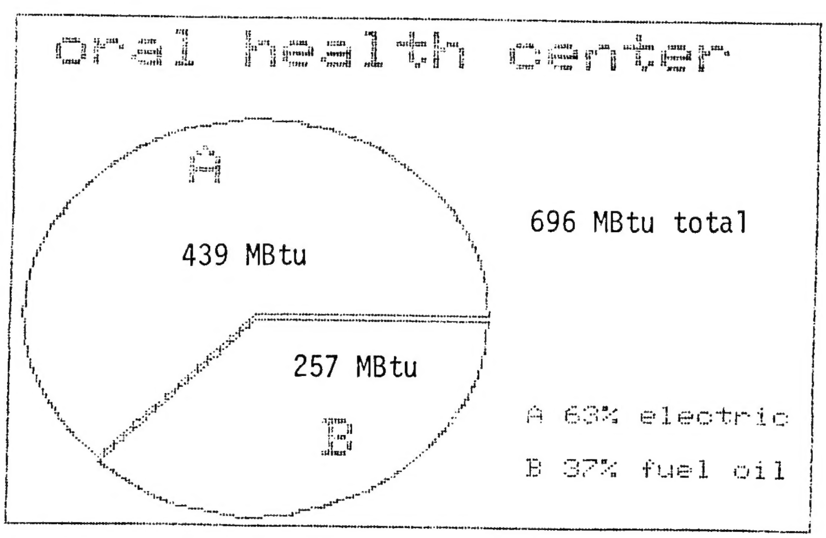


FIGURE 6-4

PROJECTED ENERGY COST
ASSOCIATED FACILITIES